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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN, THE NATIONAL IRONFOUNDING EMPLOYERS' FEDERATION, THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES' EQUIPMENT AND SUPPLIES ASSOCIATION.

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Telephone: Central 1885. Telegrams: CIRA.
The B.C.I.R.A. Scottish Laboratories are:—
Foundry Technical Institute, Meek's Road, Falkirk (*Telephone 332*).

Forthcoming Events.

DECEMBER 7.

Institute of Metals (London Local Section):—Meeting, at 7.30 p.m. "A Metallurgist's Outlook on Modern Foundry Productions" (joint meeting with the Institute of British Foundrymen), Paper by J. R. Handforth.

DECEMBER 8.

Institute of Metals (Sheffield Local Section):—Meeting, at 7.30 p.m. "Modern Application of Electric Heat," Paper by J. C. Howard.

DECEMBER 12.

Institution of Welding Engineers (North-Western Branch):—Meeting at Liverpool School of Technology, at 7.15 p.m. "Welding as applied to Ship Construction and Repair," Paper by S. E. Evans.

Institute of British Foundrymen.

DECEMBER 6.

Lancashire Branch (Preston Section):—Meeting, at 7.30 p.m. "Some Views of a Practical Foundryman," Paper by J. G. Robinson.

London Branch:—Meeting at Charing Cross Hotel, at 8 p.m. Joint meeting with the Institute of Metals.

DECEMBER 7.

Sheffield and District Branch:—Visit to the Glass and Lamp Works of the British Thomson-Houston Company, Limited, Chesterfield.

DECEMBER 8.

Middlesbrough Branch:—Meeting at Technical Institute, at 7.45 p.m. "Heat-Resisting Cast Iron," Paper by E. Morgan.

DECEMBER 12.

Lancashire Branch:—Meeting at Manchester, at 4 p.m. "Unorthodox Methods of Commercial Moulding Sand Control for the Modern Ironfounder," Paper by F. Hudson.

Foundries and Politics.

Business in Victorian days, except in the widest sense, was divorced from politics, but to-day political and actual repercussions are rapid and profound in their reaction on each individual business. This has especially been the case since the change-over from the system of free to taxed imports. Duties are increased, reduced or annulled from time to time, and these actions invariably effect some section of the foundry industry. Of course, any individual can be represented at the inquiries which are held, but some foundry owners imagine that theirs would be "a voice crying in the wilderness." This is true to a limited extent, and undoubtedly the authorities prefer representation from groups of manufacturers. For the foundry industry this is not always easy, with its present method of organisation.

To our mind, there is but one workable system capable of taking action nationally and internationally, and that is a general over-riding organisation embodying every founder within the land. This would merely mean an extension of the regional associations, as now operates within the National Ironfounders' Employers' Federation, together with associations of founders making similar lines of castings such as is typified by the British Ironfounders' Association, which very efficiently takes care of the light-castings section of the industry. Where the number is too small to have an association, then a sub-committee of those interested would meet the case.

Such an organisation as we have envisaged would have a very considerable influence with the Government, railway concerns and other bodies whose actions profoundly affect the general welfare of the industry. The smaller foundry owner would then realise that his wishes were being made known to those various select committees, tariff boards, tribunals, commissions and similar august bodies, the edicts of which are reflected in either the credit or debit side of his balance-sheet. When thinking of the activities of employers' federations, too much consideration is given by the individual to price-cutting by competitors—a definitely internal factor—and too little to the external matters, which are not so innocuous, as a cursory examination may indicate. The relationship between detached foundries and those attached to engineering works needs adjustment, and operation in water-tight compartments can be, and often is, detrimental to both.

What we suggest is a dual representation within the foundry owners' organisation, the one being of a regional character and the other based on type of manufacture. Every foundry has a definite interest in seeking this type of representation, as no other means can effect its purpose completely.

British Industries.

We have derived a great deal of pleasure from reading Dr. G. C. Allen's recent book, "British Industries and Their Organisation," for two reasons. Although the book is written from the point of view of a professed economist and while it is packed with facts drawn from official and authoritative sources, it is almost entirely free from technical terms, and the style is readable. Secondly, we were able to bring to the book technical knowledge of one of the industries with which it deals, and we found it to be singularly accurate in its references to the technical side. Books written by economists for industrialists are apt to be lacking in this respect, and it is a fair inference that if the book is accurate for one industry it is likely to be so for the remainder.

The book deals with the rise of British industry prior to the war, and illustrates its growth with reference to three great staple industries—the heavy industry, that is, coal, iron and steel; the engineering industry, including shipbuilding, marine engineering and automobile engineering; and the textile industry, including cotton and wool. It is the author's purpose to examine the decline which has set in in these great industries, and to see how far it is due to causes which are within and causes which are outside the control of the British people. The changes brought about by the war and the upheavals which have followed its conclusion are examined with a good deal of skill, and the changes which have taken place in industry since the war are described. It is thus possible to answer in a tentative way the query as to whether the present decline in these great industries heralds the approach of a national industrial decay, and what is needed to arrest this or to provide for the development of other trades which can take their places.

Founders who are apt by too close attention to their own industry to lose perspective of the larger field of which that industry forms a part will be interested in the picture which this book presents of British industrial activity—its causes, its fluctuations and its possible future.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Technical Control of Small Foundries.

To the Editor of The Foundry Trade Journal.

Sir,—The lecture on the above subject given by the Director of the B.C.I.R.A., and reported in last week's Journal, should undoubtedly arouse interest and attention among those concerned in the subject. At frequent intervals over many years the question of the position and usefulness or otherwise of the chemist in the foundry industry has arisen, such that it appears that this subject has acquired the status of a seasonal phenomenon, or one of those inherent problems peculiar to the foundry. A statement, therefore, from such an authority as Mr. Pearce will receive more than usual attention.

It is noted that Mr. Pearce discourages the selection of chemists for technical control posts in small foundries, for the responsibilities of raw materials, metal mixing, melting and sand control. Now, considering that the recommended responsibilities and control tests are based on the results of scientific study of foundry practice (and which, we understand, is the function of the B.C.I.R.A.), it is surprising to learn that a person of scientific training is not recommended as the more suitable type.

Turning to fundamentals, the study of cast-iron practice is a branch of metallurgy, and metallurgy is applied chemistry to the study of metals, while chemistry, both pure and applied, includes basic physical laws and the applications. Now, whether considering cast iron, melting practice, refractories or any phase of foundry practice, surely chemical and physical laws determine their properties, applications and technical control. On logical grounds alone, then, it is reasonable to conclude that there exists a definite and important position in the foundry industry for the fully trained chemist specialising therein. As with the steel and non-ferrous branches, where the chemist is already recognised as an essential part of the technical control, it appears unquestionable that as time goes on a similar state will be arrived at in the foundries. Personally, then, I would recommend that the industry should encourage *now* the entry of young chemists of the *right type* to specialise in and study the engineering and practical aspects of the foundry; and by following the developments and researches of such authorities as the B.C.I.R.A. they would be uniquely fitted to exercise technical control. The smaller foundries appear to offer decided prospects in this direction.

Referring to the relations between practical foundrymen and chemists, Mr. Pearce "hit the nail on the head" when he stated that some of the differences are more personal than technical. It must be remembered that the entry of the chemist into the engineering industries was fraught with difficulties and differences, and it is only of recent years that common sense and modern progress demand the mutual co-operation as an essential. It is generally recognised that the ironfoundry industry is one of the last to look to scientific application, and hence it is only natural that newly-recruited chemists will meet with various mixtures of reception. However, the existing prejudices will undoubtedly disappear as science advances and time goes on.

So far as chemists, generally, are concerned, some definition and consideration seems essential in order to remove some general misapprehensions. In the first place, it is very unfortunate that anyone who gains a knowledge of elementary metallurgy and analyses, perhaps by following up a session or two of evening classes, can assume the title of chemist (or metallurgist), in spite of the extremely narrow limits of their chemical and physical training. The existence of an abundance of such, particularly at a cheap wage, is evident to anyone who has travelled around the foundry and engineering industries. In my opinion, this is one of the main factors that have contributed to the foundryman's lack of confidence in chemists. Coupled with these, most of us have seen and are familiar with the dangers of those who "dabble" in science, and evidences of this are continually exhibited in published Papers and journals.

In the second place, it must be realised that, as with all other classes of beings, different *types* of chemists exist, and it is generally recognised that there are two distinct types. There are those whose interest and work is wholly concentrated in laboratory work, analyses, research and theoretical studies, with lesser or very little interest and appreciation of practical industry. The other type are those whose abilities trend towards the commercial and practical applications of science, and who are sufficiently practical minded to appreciate works practical problems. Evidences of such industrial chemists exist throughout the various branches of the engineering industries.

Thus, it is the writer's contention that the foundry industry should offer sufficient prospects to attract and encourage young qualified chemists of the right type, who are prepared to explore the engineering and practical aspects of founding, for its possibilities in scientific control and development.

I note that Mr. Pearce, in reply to discussion on his Paper, alluded to the also frequent problem of different analysts giving different figures for the same sample of cast iron. It is not clear as to whether the differences are attributed to the analysts, methods used or the material tested, but I am confident that Mr. Pearce will be first in agreeing that heterogeneity of composition is more peculiar to cast iron than any other general industrial metal. Also, in the form of drillings, etc., segregation and loss of graphite so readily occurs that even the same analyst can find totally different results from the same original source of metal, and that exceptional precautions are necessary in sampling, packages, etc. As to methods of procedure, it is noted that the B.C.I.R.A. have issued recommended methods, which, although not indicating anything new or novel to many of us, certainly ought to eliminate any variations attributed to analytical practice. The question of analyses of cast iron is so frequently debated from the point of view of different chemists' results that it is surprising that the heterogeneous nature, sampling, etc., which is most often the direct cause of differences, is completely forgotten when foundrymen are so anxious to criticise the chemist.

I have attempted to indicate some of the aspects from the mere chemist's point of view, in spite of the general impression that might be concluded from Mr. Pearce's lecture; for, while admittedly directed towards small foundries, the lecture will no doubt interest foundrymen generally. It is quite a misapprehension to regard chemists as analysts only, for the daily production of lists of figures constitutes but a small fraction of the services rendered by chemists in industry throughout.

In conclusion, it would be interesting to have Mr. Pearce's more general views, as the trend of circumstances do not appear synonymous with his recent remarks. Also, we read that the B.C.I.R.A. have just elected a distinguished chemist as their President, while their list of advisers and committees include several chemists. Finally, are not chemists increasing in number in the foundry industry?—Yours, etc.,

"Chem-met."

Birmingham, November 22, 1933.

Mr. Walter Runciman, the President of the Board of Trade, is to open the new 700-ft. extension to Newcastle Quayside on December 11.

Nickel Prospects.

By "Onlooker."

It has been stated that production of copper at the mines of the International Nickel Company in Canada has been considerably increased and that the Ontario refinery is busier than for a long time past. Presumably the company is disposing of its copper, although demand for the red metal is not any too good at the moment, but what does appear evident is the fact that there has been a rapid uplift in the demand for nickel, to meet which the producers have been obliged to speed up output and incidentally to increase their production of copper which occurs in conjunction with nickel in the ore.

There was a time when the uses of nickel were more circumscribed than they are to-day, and in pre-war days when Europe was preparing for Armageddon demand for this metal was largely in connection with armour plate, ammunition, etc., but to-day there is comparatively little call for this metal in such connections. The nickel silver trade is going through a depressed period, but things are rather better than they were, and a fair tonnage of nickel is passing into consumption in this direction. This alloy, composed of nickel, copper and spelter, the nickel contents varying from 20 to 30 per cent., is a pure white metal resembling silver and is capable of taking a high degree of polish. Naturally the higher the nickel content the whiter the metal, and the better qualities—and incidentally more expensive ones—are used for the manufacture of spoons and forks, while the alloys of lower nickel content form a basis for plating with silver.

Apart from nickel silver, we find nickel entering into the manufacture of coinage, but this outlet, though important in its way, does not absorb a very large tonnage of the metal, as the units of use are of course small. In all, nickel enters into the composition of something like one hundred different alloys, many of which are still in the early stages of development and may be counted upon to assume greater importance in due course. To discuss these in a short article is, of course, impossible, but they have a wide range of industrial application, and some of them have come well to the front in recent years in the electrical trades.

One of the best known commercial alloys is Monel metal, with its high tensile strength and extensive elongation, while nickel alloyed with copper to the extent of from 20 to 30 per cent. gives an alloy popular with tube makers for condenser work, etc. These tubes stand up very well against corrosion either from acids or alkalis, and even where foul water is in use they give a long life. In connection with military ammunition an alloy of 20 per cent. nickel and 80 per cent. copper is used, these "bullet envelopes," as they are called, being popular as scrap after ammunition has been broken down at the arsenals. Added to steel in small quantities greater strength is obtained, and where big strains have to be carried, as in building construction, this factor is of great value.

During the difficult period following the war the nickel producers have scored over the tin and copper interests in keeping the price of their metal stable, and up to the autumn of 1931, when Britain's abandonment of the gold standard brought fluctuations in the exchange, the quotation hardly varied at all from £170 per ton. Since September of two years ago there have been ups and downs, the price rising at one time to £260, but America's departure from a gold basis has brought about a lowering of this value, and to-day's figure is between £225 and £230.

No account of the nickel position however brief would be complete without some reference to the Bureau of Information on Nickel, which has done so much during the past decade, not only to popularise the use of this metal, but to deal with queries and problems.

Production and Properties of Superior Cast Iron.

WITH SPECIAL REFERENCE TO MEEHANITE.

By Oliver Smalley.

In recent years there has been much activity and discussion regarding the manufacture of improved cast irons and their properties. Much of this activity has had to do with the addition of alloys—nickel, chromium, molybdenum, and so forth. However, superior irons have been made without the introduction of alloys by proper attention to physical constitution, super-heating, refining and/or heat-treatment. One of the outstanding advances in this direction is the Meehanite process.

Regarded from a strictly metallurgical standpoint, ordinary grey cast iron is an intermediate between an unrefined and refined product. It differs from true alloys of ferrous base by the presence of suspended graphite particles when in the molten state. It is this peculiarity of certain grey irons that is responsible for the low strength, mechanical weakness and inconsistencies in service of castings from badly-run grey-iron foundries.

During the past 20 years much study and research have been developed to this phase of the subject, and almost every process developed to improve the physical characteristics has consciously and unconsciously attempted to control graphitisation, whether resort has been had to use of steel scrap in the mix, whether the carbon

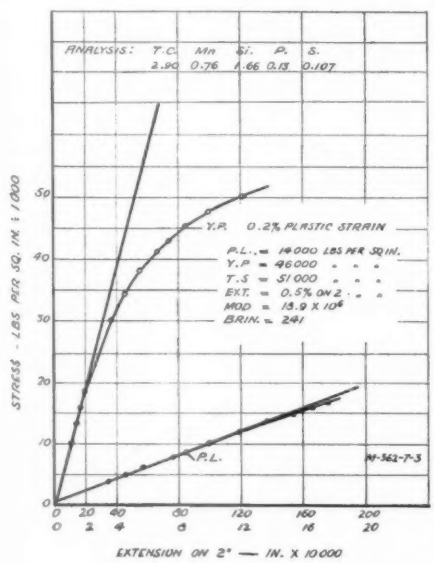

ANALYSIS: T.C. Mn Si. P. S.
2.90 0.76 1.66 0.13 0.107
Y.P. 0.2% PLASTIC STRAIN
P.L. = 14000 LBS PER SQ.IN.
Y.P = 46000 " " "
T.S = 51000 " " "
EXT. = 0.5% ON 2 " " "
MOD = 13.9 X 10⁶
BRIN. = 241
P.L.
M-362-T-3
STRESS - LBS PER SQ. IN. ÷ 1000
EXTENSION ON 2" — IN. X 10000

Fig. 1.—Tension Test Curve on Meehanite Metal As-Cast.

and silicon have been reduced by special mixtures in melting conditions, whether hard iron has been graphitised by pouring in heated moulds or whether alloys or heat-treatment have been involved.

The results of all of these different methods of attempting the same object are seen in the superior cast irons possible to-day, although progress has not been proportional to the scientific attention and research that have been applied. To some extent this can be explained by the necessity of retaining the identity of what is commonly understood as "common cast iron" together with an economic advantage over steel. In other words, the foundryman, to hold and extend his field, must furnish castings that are consistently uniform and that have a superior combination of physical properties without involving the costly processes and increased care that are necessary to the manufacture of any completely refined ferrous-base alloy, whether it is a steel or any other alloy casting, stamping or forging.

The highly-developed technical and plant efficiency of the manufacturers of these latter and their low cost of production have, as it were, tied the hands of the average foundry owner in his attempts to improve his product and still retain some commercial advantage over other products made in steel, aluminium alloys or bronze.

Designers' Attitude towards Cast Iron.

With all his knowledge of materials and their behaviour, the engineer has no satisfactory system of choice of working stresses. It is also unfortunate that most of his studies on the physical testing of grey cast iron have been done without due regard to the metallurgical nature of the material. Most modern engineering text-books describe cast iron as a material that does not give a straight-line relation between stress and strain in a tensile test. In other words, it does not possess true elastic properties. They also say that it is a "brittle" material.

It is unfair that grey cast iron should be so branded for modern cast irons are made that have both true elastic properties and are *not brittle*, as will be shown later. It is also unfortunate that most text-book tests were made on cast irons that were not meant to be anything but the free-cutting ornamental variety.

This attitude toward grey cast iron is not altogether the engineers' fault. Metallurgists and foundrymen have probably never appreciated fully the engineers' point of view. Tensile tests on grey cast iron, *e.g.*, to give accurate measures of elastic constants, are difficult to make and require special equipment, hence concentration has been given to the transverse test because it can be made cheaply. In this test, load and corresponding deflection values are determined and substituted in the well-known beam formulæ to obtain modulus values. Such modulus values mean little, *e.g.*, it has been shown by Adamson and Bell[1] that common grey iron when tested transversely by means of bars 1 in. by 1 in. over a 36-in. span, the modulus value, computed on the basis of deflection at fracture, may be 11,500,000 lbs. per sq. in., whereas for the same material with the same size test-bar on a 12-in. span the modulus becomes 6,500,000 lbs. per sq. in. Presumably the material in these different test-bars is the same—then the explanation must be found on analytical grounds. Possibly, for instance, in the tests with the shorter bars, the supports deflect more, since the applied loads are greater for the same cross section. Such an effect might account for a decrease in modulus. In design work, however, the engineer must know what is really the numerical value of E, for it is one of the most important material constants. Its physical meaning is "the stress which would be necessary to stretch a bar to double its length."

If he uses steel, then very little error arises by using 30×10^6 lbs. per sq. in., because steel in general averages this value. With cast iron, according to such publications as cited above, there may be variations from 6,000,000 to 10,000,000 lbs. per sq. in., and with such variations it would be impossible for the designer to put any reliance on his calculations, and in this day and age such reliance must be obtained.

Figs. 1 and 2 show correctly-made elastic limit curves of cast iron made by the Meehanite process. The former made by process "A" the latter by process "AF" heat-treated. Here it will be seen that Meehanite grey iron does give a straight-line relationship between the stress and the strain, the true elastic limit of process "A" being 6.4 tons per sq. in. and the yield point 21 tons per sq. in. Process "AF" Meehanite heat-treated shows an elastic limit of 9.5 tons per sq. in. and a yield point of 27 tons per sq. in. The modulus of process "A" iron is 19,000,000 lbs. per sq. in. and for process "AF" is 26,000,000 lbs. per sq. in. In other words, here is grey cast iron that conforms to the concepts of true alloys.

[1] Carnegie Memoirs, 1927.

Table I.—*Tensile Test Values of Meehanite, as Compared with Other Structural Materials.*

Materials	Ultimate strength. Tons per sq. in.	Modulus of elasticity. Lbs. per sq. in.	Brinell hardness.
Ordinary cast iron..	12	6,000,000 to 10,000,000	162
Steel casting ..	29	29,000,000	141
Steel forging ..	32	30,000,000	141
Welded joint ..	23	—	156
Meehanite, proc. "A" (as-cast) ..	24	20,000,000	227
Meehanite proc. "AF"	50	26,000,000	270

Brittleness.

Photomicrographs, Figs. 3 and 4, were taken from castings, 3-in. section, both magnified 100 times. Fig. 3 represents ordinary semi steel, such

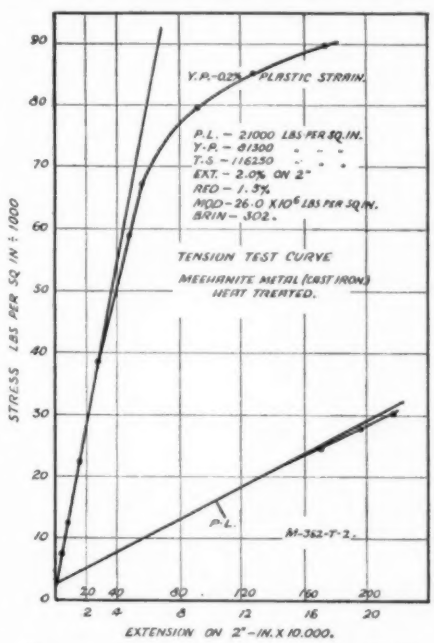

Y.P.-0.2% PLASTIC STRAIN.
P.L. - 21000 LBS PER SQ.IN.
Y.P. - 61300 " " "
T.S - 116250 " " "
EXT. - 2.0% ON 2"
RED - 1.5%
MOD - 26.0 X10⁶ LBS PER SQ.IN.
BRIN - 302.
TENSION TEST CURVE
MEEHANITE METAL (CAST IRON)
HEAT TREATED.
P.L.
M-362-T-2.
STRESS LBS PER SQ IN ÷ 1000
EXTENSION ON 2"-IN. X 10.000.

Fig. 2.—Tension Test Curves on Heat-treated Meehanite Metal.

as was used in the transverse test referred to. Fig. 4 is process "A" Meehanite. The influence of the graphite on the ductility or toughness qualities of the two cast irons can well be visualised, whilst it is easy to see that structures intermediate between these two will give different degrees ductility.

The designing engineer would like to know more about this property of toughness or ductility. Unfortunately, he really does not know when ductility ends and brittleness begins in either cast iron or steel. It is of rare occurrence for metals to fail under static loading, the source of most of the engineering failures being due to fatigue. In fatigue failures even soft and so-called ductile metals like copper, nickel, mild steel and so forth finally snap off short because a crack has been produced and is propagated till the cross-section is reduced to breaking point.

Continued research and experimenting to measure fatigue values, preferably expressed as endurance limits, have been conducted since the Wohler studies in 1852. Fatigue or endurance limit is a fundamental property, and all good design is predicated on tensile and fatigue characteristics. When the stress conditions imposed on a structure are of such type that they are static, the tensile-test values are sufficient.

Fig. 3.—Semi-Steel. Unetched. × 100.

When the stress conditions continually change, setting up stress fluctuations, a material fails at stress values much below those obtained in a static-tensile test, *e.g.*, a steel forging may have a tensile of 32 tons per sq. in., but when subjected to stress reversals of equal intensity, such as in a rotating shaft loaded at the free end, may fail at a stress of 14 tons per sq. in. These facts indicate how important it is that in the economical use of material, the stress conditions be well known to the engineer, and also the characteristics of his materials under these conditions.

Fig. 5 shows the SN fatigue curves of Meehanite. These compare with other materials as follows:—

Material.	Fatigue strength. Tons per sq. in.
Ordinary cast iron ..	5.0
Steel forging	14.5
Welded joint	5.0
Aluminium bronze ..	12.5
Duraluminium ..	6.75
Malleable iron	10.75
Copper	4.5
Meehanite (process "A")	9.5
Meehanite (process "AF") (heat-treated)	12.75

Meehanite thus compares favourably with the so-called ductile metals and alloys such as nickel, copper, bronze and soft steel, whilst the fatigue strength of the commonest cupola-melted Meehanite is nearly twice that of welded steel. Other significant physical characteristics of the Meehanite irons that establish them as improved material for engineering construction are as follow:—

(1) Brinell Hardness—as-cast, 160 to 280 as required.

(2) Brinell Hardness—heat-treated, 160 to 600.

Fig. 4.—Meehanite made by Process A. As-Cast. Unetched. × 100.

(3) Compression Strength—82 tons per sq. in.

(4) Transverse Strength—up to 6,000 lbs., 1.2-in. bar broken over 12-in. centres.

(5) Torsion—½-in. bar, 10 in. long, fibre stress—11 tons per sq. in. Total Twist—31 deg.

(6) Charpy Impact—up to 10-ft. pounds.

(7) Stanton Impact—2,700.

(8) Specific Gravity—7.49.

(9) Melting Range—1,360-1,383 deg. C.

(10) Thermal Expansion—0000058—mean coefficient of linear expansion 1 deg. Fah. between 70 deg. and 500 deg. Fah.

Under temperature influences Meehanite retains its strength up to 480 deg. C., as is shown by the following table:—

Tensile strength. Tons per sq. in.	Temperatures. Deg. C.
23.75	21
23.55	204
23.5	371
24.25	427
22.9	482
18.33	538
13.2	645

Non-Growth Scale-Resisting Properties.

In that the form of graphite is such that continuity and interlocking are avoided, ordinary process "A" or process "B" have good non-growing properties at higher temperatures than are likely to be encountered under the influence of superheated steam.

Where heat conditions have to be encountered at temperatures up to 870 deg. C., process "M" or process "HR" Meehanite is substituted. The former is designed so that the graphite is in nodular form, and the carbides are stable

Fig. 6.—Meehanite made by Process A. As-Cast. × 1,000.

under temperature influences up to 593 deg. C. Exceeding 593 deg. C., scale resistance becomes equally important with non-growing properties and Meehanite process "HR" is designed to meet this requirement.

Mass Influence.

This was the subject of a recent discussion in the A.S.T.M. Various foundries were invited to submit test-bars 0.75 in., 1.25 in., 2 in. and

3 in. dia., and from these tensile test-bars were machined and pulled.

The average results are given below:—

Tensile test of grey iron—

Dia. of bar, in in.	0.75	1.25	2.0	3.0
M.S. tons per sq. in.	12.3	11.6	8.2	6.5

Tensile test-bars were made in Meehanite process "A" metal in increasing-size bars up to 6 in. with the following results:—

Dia. of bar in in..	1.2	2.0	3.0	4.0	6.0
M.S. tons per sq. in.	23.95	24.25	23.75	22.75	21.25

These results are obtained from a 6-in. solidity penetrating power value and adjusting the carbide balance of each iron so that it is the same in each case. This is one of the outstanding features of the Meehanite process. Because of this uniformity, the strength of any machine element is directly proportional to its cross-sectional area. In other words, in designing, assurance is given that here is a cast iron that is dependable in the engineering sense, and every square inch of cross-section carries its full share of operating load.

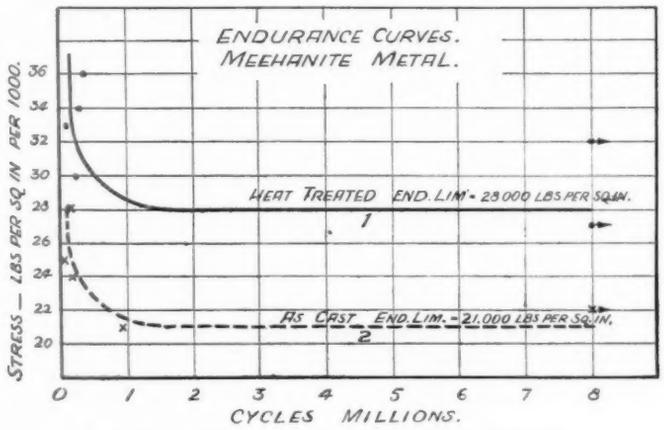


FIG. 5.—ENDURANCE CURVES IN MEEHANITE METAL.

The force of this is seen in pressure castings. Medium-grain cast irons will serve generally for castings to retain normal water pressures, *i.e.*, up to 300 lbs. per sq. in. test-pressure, if this medium-grained cast iron is not accompanied by casting defects such as shrinks, blowholes and sponginess. When the castings are to withstand temperatures and gases, coarse and medium-grained irons are not advantageous to use at low pressure. As the pressure increases, fine-grained and uniform density become more essential, whilst in the case of castings to withstand the kerosene pressure-test the slightest defect will be revealed. Process "A" Meehanite has been used with great success in valves for high-pressure gas-lines and high-pressure petroleum lines. These valves are tested with air and kerosene to test-pressures taken as high as 6,000 lbs. The valves that are tested up to 6,000 lbs. have a section of 2 to 2½ in. High-pressure gas meters and regulators are other examples of what is possible from this modern grey iron.

Regulator bodies are in daily production that pass 6,000 lbs. per sq. in. in hydrostatic pressure. Meter bodies whose outer section approximates 1 in., but which are divided into two parts by a light diaphragm which is only ⅜ in. thick, are subject to a testing pressure of 1,250 lbs. per sq. in.

Manufacture.

Meehanite cast iron is made in the cupola, electric or air furnace. When made in the cupola the process makes use of considerable scrap steel. By the technique of manufacture and the application of the process of decomposition of excess carbides and controlling the physical constitution of the remaining carbides, metallurgical supervision is positive. In other words, not only is it possible accurately to control graphitisation and produce a given graphite content at will, but the form of the graphite is equally well under control.

The essential difference between ordinary cast iron and Meehanite cast iron is that the graphite of the former is of the primary variety, whilst in Meehanite it is of the secondary variety. Figs. 4 and 6 show this; the former is taken at a magnification of 100 times, the latter at 1,000 times. This structural feature explains the remarkable toughness of Meehanite irons as measured by the rotary fatigue test, Charpy and Stanton impact tests.

In ordinary practice the range of composition permissible varies according to the specific requirements of the casting to be made. Maybe among the unique characteristics of cast irons made under the Meehanite process is that the silicon content of the iron need not be held within the strict limitations that are necessary to semi-steel and alloy cast irons.

Possibly the greatest practicability of the process is the facility with which each ladle of molten iron may be changed as it comes from the furnace so as to meet any given set of conditions in the way of mass influence as it affects strength, hardness and machinability. It also has the advantage of being able to meet Brinell hardness figures up to 275 and still maintain good machining qualities.

Heat-Treatment.

The presence of coarse flakes of graphite and the instability of the carbide of ordinary soft grey irons are responsible for the difficulties and uncertain results obtained by heat-treatment or annealing, whether the desired object be to obtain greater strength, hardness, ductility or machinability.

As has been shown by Fig. 5, process "A" Meehanite compares with carbon tool steel, the essential difference between the two being the presence of graphite in varying amounts which is controlled by calcium silicide additions.

Like ordinary tool steel, Meehanite castings may be hardened by rapid cooling from above the critical change point and softened by prolonged cooling at or about the critical point. These changes in the hardening carbide of Meehanite cast irons obviously affect the physical properties much in the same way as they affect the ordinary 0.9 per cent. carbon steel, which consists of wholly pearlitic structure, as indicated by Fig. 5, but with the absence of free graphite.

The tensile strength of 0.8 to 0.9 per cent. carbon steel with this structure is approximately 55 tons per sq. in. If reheated and allowed to cool very slowly in the furnace, the tensile falls to 40 tons per sq. in., but if it were reheated to above the critical and allowed to cool freely in air, the strength would be raised to 63 tons per sq. in. Similarly, if quenched in water from above the critical change point, it will be glass-hard and Brinell 675, but if it were allowed to cool slowly a Brinell of 165 would be found.

Meehanite cast irons are equally susceptible to these conditions of change by heating and cooling. By heating to above the critical change point and quenching, they may be made glass-hard, and if cooled they will be softened; similarly is the strength and toughness affected by the rate of cooling.

The technique of manufacture of Meehanite responsible to heat-treatment is somewhat important, for graphitisation must be done with considerable accuracy and to such a degree that heating for the purpose of hardening does not decompose any of the hardening carbide. This is the common trouble in the heat-treatment of ordinary cast iron, and the same trouble ensues with Meehanite castings that are not specified "to be heat-treated." In other words, if a Meehanite casting is made to have 23 tons tensile and endurance limit of 9.5 tons, and to be free machining, then it would be unwise to decide suddenly to heat-treat that casting. In order to prevent misunderstanding, Meehanite to be heat-treated is designated process "A" heat-treated and process "M." The former hardens by quenching in water, the latter by oil quenching.

Cardiff Engineering Exhibition.

The twelfth annual Engineering Exhibition, under the auspices of the South Wales Institute of Engineers, was opened at Grey Friars Hall, Cardiff, on November 22 at 2.30 p.m., and will remain open until December 2. The Exhibition will keep open daily (Sunday excepted) from 2.30 p.m. to 8.30 p.m., except on Friday, December 1, when it will close at 6 p.m. The opening ceremony was performed by Mr. D. Morgan Rees, J.P. (President of the South Wales Institute of Engineers), at 2.30 p.m. on Wednesday, November 22. The Lord Mayor of Cardiff (Alderman A. E. Gough, J.P.) offered a civic welcome to the exhibitors, and, in the absence of Mr. F. Llewellin Jacob (Chairman of the Monmouthshire and South Wales Coal Owners' Association) who was unable to attend, Mr. Trevor L. Mort (Vice-Chairman of the Association) spoke.

Iron and Steel Output in October.

The National Federation of Iron and Steel Manufacturers state that there were 74 furnaces in blast at the end of October, the same number as at the beginning of the month, two furnaces having been blown in and two having ceased operations during the month. The production of pig-iron in October amounted to 373,300 tons, compared with 359,700 tons in September and 275,600 tons in October, 1932. The production includes 102,400 tons of hematite, 175,400 tons of basic, 78,500 tons of foundry and 8,500 tons of forge pig-iron. The output of steel ingots and castings in October amounted to 668,300 tons, compared with 669,000 tons in September and 439,800 tons in October, 1932.

Imported Aluminium.

The Import Duties Advisory Committee give notice of an application for an increase in the import duty on (*a*) plates, sheets, strip, circles and discs, bars (other than notch bars), rods, wire, tubes, angles, shapes and sections of aluminium or alloys of aluminium containing more than 50 per cent. by weight of aluminium; and (*b*) aluminium foil. Representations which interested parties may desire to make should be addressed in writing to the secretary, Import Duties Advisory Committee, Caxton House (West Block), Tothill Street, London, S.W.1, not later than December 11.

The Practical Benefits of Green-Sand Testing.

At the November meeting of the Middlesbrough Branch of the Institute of British Foundrymen, presided over by Mr. J. E. Mercer, Mr. N. D. Ridsdale (Convener of the Sands Sub-Committee) gave a *résumé* of the "Report on Routine Methods for Testing Green Sands" presented to the Annual Conference at Cardiff in June, 1933, and reprinted in The Foundry Trade Journal of July 27, August 3, September 7 and 21, and October 5, 1933, with discussion. This Report recommends the following methods should be standardised for use in Great Britain:—

For Moisture.—The "Speedy" (patent) moisture tester;

For Ramming and Test-Piece.—The A.F.A. standard drop ram and 2-in. dia. by 2-in. long test-piece;

For Permeability.—The A.F.A. apparatus or Richardson's modification. (Note.—The A.F.A. method of expressing permeability is as the number of cub. cm. of air which would pass through 1 cub. cm. of sand in 1 min. at a pressure difference of 1 grm. per sq. cm. Hence a sand with a permeability number of 80 allows twice as much gas to pass through it in a given time as a sand with a permeability number of 40); and

For Bond Strength.—The A.F.A. test-piece, using B.C.I.R.A. compression apparatus. (Note.—The A.F.A. method of expressing "bond" is as lbs. per sq. in. required to crush the standard rammed specimen.)

New Exhibits.

Mr. Ridsdale exhibited the Simon Carter (patent) Moisture Tester, which is an electrically-heated oven at constant temperature (automatic) with ultra-efficient ventilation enabling a single sample to be dried and weighed in 8 min., or 30 samples per hr., by one operator, and the A.F.A. mould-hardness tester, which is an instrument the size of an ordinary watch by means of which a hardness test of a mould may be made in a few seconds. The tester is pressed against the mould surface and the reading noted on the dial.

Typical Sand Problems.

Mr. Ridsdale then detailed a few typical problems.

(1) An ironfounder had been accustomed to use floor sand with 30 per cent. new milled sand added, and the mixture simply turned over and riddled. Tests on this mixture showed:—

Moisture.	Permeability.	Bond strength.
6 per cent.	12.6 c.c./min.	4.8 lbs./sq. in.

By milling the whole mixture it was found that by reducing the new sand to 15 per cent. the properties of the sand were as follow:—

Moisture.	Permeability.	Bond strength.
6 per cent.	15.0 c.c./min.	7.6 lbs./sq. in.

The bond strength was much improved and the permeability a little better, whilst the more even texture of the sand considerably improved the skin of the castings.

(2) An ironfounder had been accustomed to obtain regular supplies of a certain kind of moulding sand. Owing to a breakdown, supplies were temporarily suspended. Samples from two other sources were obtained and comparative tests were quickly made, with the following results:—

	Moisture, per cent.	Permeability, c.c./min.	Bond strength, lbs./sq. in.
Regular supplies..	4	80	5.0
Substitute No. 1..	6	30	5.5
„ No. 2..	6	50	4.8

Supplies from substitute No. 2 were used on account of better permeability than No. 1, but the original sand was reverted to as soon as possible, as it was realised that the lower permeability of No. 1 might cause trouble in a month or so as the permeability of the floor sand steadily diminished.

The Sands sub-committee is now occupied in correlating tests with practice, and hopes to report on this in due course. Meanwhile the following table from American practice may be of interest to British founders, though it may not be a suitable guide for practice in Great Britain.

Possible Sand-Test Values (by Dietert).

Kind of casting.	Type of ramming	Per cent. moisture.	Compressive strength, lbs./sq. in.		Permeability, c.c./min.
			Green.	Dry.	
Stove plate	Squeeze	8.5/9.5	4.4	19	9
8-lb. plate	Jolt squeeze ..	8.0/9.0	3.8	33	15
15-lb. plate	„ „ ..	7.7/8.7	3.8	40	25
20-lb. jobbing	Hand	7.0/8.0	6.0	40	35
Radiators	„	6.0/7.0	3.5	52	35
Bath tubs	Sandslinger ..	5.0/6.0	3.6	46	70
Cylinder blocks	S/S or jolt ..	6.0/7.0	5.0	44	80
Car wheels	Jolt	7.5/8.5	4.7	40	130
Boiler sections	„	6.0/7.0	4.3	40	80
„ „	Sandslinger ..	5.5/6.5	4.2	40	80
Pipe	Jolt	8.0/9.0	4.0	48	300
„	Pneumatic ..	6.0/7.0	4.0	48	300
Plough	Jolt	6.0/7.0	4.7	47	30
Steel plate	Jolt squeeze ..	3.0/4.0	5.5	50	110
Fly wheels	Sandslinger ..	6.0/7.0	4.1	40	100
Bronze bushings ..	Jolt	6.0/7.0	3.2	39	35

(3) A mild Erith loam (milled) showed the following tests:—

Moisture.	Permeability.	Bond strength.
6.2 per cent.	46.0 c.c./min.	4.3 lbs./sq. in.

What effect on the properties would be brought about by the addition of 15 per cent. coal dust?

Mere *mixing* with coal dust and riddling showed:—

Moisture.	Permeability.	Bond strength.
3.2 per cent.	38.3 c.c./min.	5.1 lbs./sq. in.

whilst *milling* with coal dust and aerating showed:—

Moisture.	Permeability.	Bond strength.
3.0 per cent.	38.4 c.c./min.	10.2 lbs./sq. in. (note the increase)

(4) A founder was called upon to make a heavy casting in "strong" loam at short notice, but was short of strong loam. On inquiring in the district the only loam he could get quickly was the mild grade. What was he to do?

The mild and strong loams gave the following tests:—

	Moisture, per cent.	Permeability, c.c./min.	Bond strength, lbs./sq. in.
Mild ..	6.2	46.3	4.3
Strong ..	6.0	26.3	11.6

A good refractory bonding clay was obtained and a series of tests were made after milling the mild loam with different additions of clay. The following results were obtained:—

Per cent. clay added.	Moisture, per cent.	Permeability, c.c./min.	Bond strength, lbs./sq. in.
10 ..	5.0	30.0	7.0
15 ..	6.0	21.3	10.5
20 ..	7.0	17.5	13.0

It was clear that the mixture with 15 per cent. clay had properties sufficiently similar to the "strong" loam, so this mixture was used for the job.

(5) A steel founder wished to find a refractory clay with the highest possible bond for making synthetic moulding sands. Clay "A" was offered at 25s. a ton and clay "B" at 20s. Silver sand was milled, under standard conditions, with different amounts of each clay, and tests were taken which showed that 20 per cent. of clay "A" gave the same bond and a much better permeability than clay "B," viz.:—

	20 per cent. clay "A."	30 per cent. clay "B."
Moisture ..	4.0 per cent.	6.0 per cent.
Permeability ..	82.0 c.c./min.	37.1 c.c./min.
Strength ..	8.1 lbs./sq. in.	8.0 lbs./sq. in.

Hence the clay "A" at 25s. was worth 30s. a ton compared with clay "B," apart from the advantages of less bulk to handle, lower moisture and higher permeability, etc.

(6) *Mould Hardness.*—A foundry manager, making repetition castings by machine moulding, had sent a sample of his sand to be tested, and it appeared to be satisfactory, but in practice the castings indicated that the sand lacked permeability. By means of the mould-hardness tester it was found that the hardness of the mould was much greater than the standard rammed specimen, and when the ramming was diminished to give hardness corresponding to the standard rammed specimen, no further trouble was experienced.

Money Saving.

Probably the greatest saving of all is brought about by regular testing, eliminating troubles which result in faulty castings, *e.g.*, excessive moisture, low permeability, bad skin, etc. Next to this, considerable economies can be effected by control tests which avoid an excessive amount of new sand being used. Finally, sands from new sources can be tested on a small scale and selected according to merit and price before being given a practical trial at the risk of disappointment and spoilt castings.

The meeting was of special interest owing to its members having been invited to bring samples and to prepare green sands to be tested at the meeting, and some samples were dealt with as a result.

A number of samples, milled and unmilled sands, were exhibited for inspection, showing the moisture, permeability and bond strength in each, so that members could compare the appearance and "feel" of the samples with the test figures.

One specially surprising sample, containing moisture 6 per cent., permeability 35.0 c.c./min. and bond strength 4.8 lbs. per sq. in., was handed round for the members to guess its nature, and it transpired that it was a mixture of silver sand milled with 15 per cent. of coal dust. Considerable interest was aroused in the bond strength of this sample.

Estimation of Manganese.—High percentages of manganese can be estimated volumetrically by oxidation of the metal in nitric-acid solution with potassium chlorate, then dissolving the precipitate in hydrogen-peroxide solution acidified with sulphuric acid and titrating the excess peroxide with potassium permanganate, according to F. W. Scott in the "Chemist and Analyst." This method is suitable for Mn estimations on ferro-manganese, spiegeleisen and basic open-hearth slag, in the latter preliminary precipitation of the silica being necessary.

Grey-Iron Castings for Laundry Machinery.*

By J. Longden.

There is offered to the modern laundryman, by manufacturers of laundry machinery, a wide range of mechanical aids to his work. In consequence, there are few industries which are more highly mechanised than the laundry trade. The machines in use include, in an extensive range of designs and capacities, washing machines, hydro extractors, ironing machines and presses. Designers of these various types of machines are continually introducing improvements of one kind or another, with a view to increasing their capacity or the quality of the work done by them. The modern laundry machine is, therefore, a first-class engineering job, making a serious call upon the capabilities of those engaged in their construction. Upwards of 95 per cent. of the material built up into these machines consists of castings, in cast iron, bronzes, brasses and aluminium. The bulk of these castings, however, up to about 97 per cent., are made in grey cast iron, and it is to the making of a few representative types of these iron castings that attention is here directed.

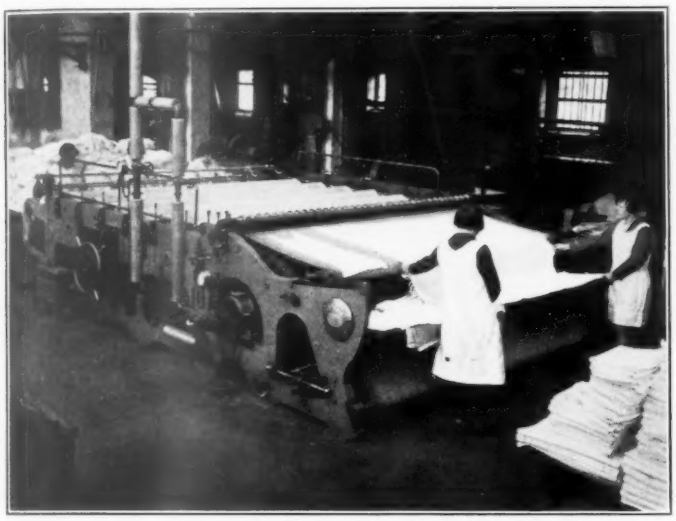


FIG. 1.—TULLIS IRONING MACHINE IN SERVICE.

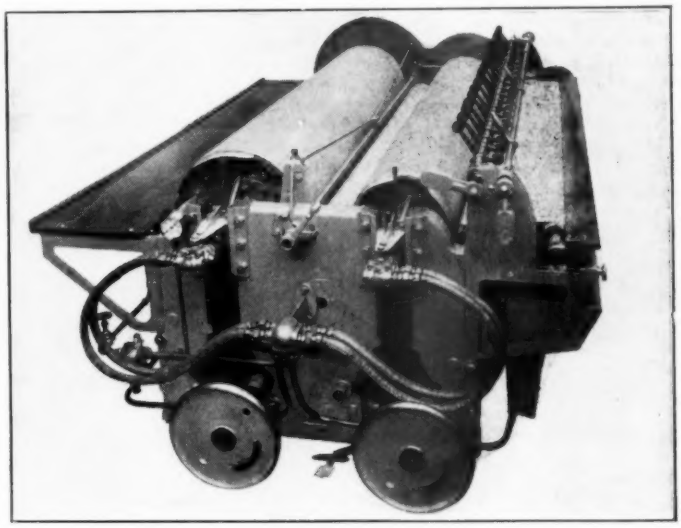


FIG. 2.—TULLIS STARCHWORK IRONING MACHINE.

An ironing machine may weigh anything up to 23 tons, depending upon the number of rollers, which may vary from one (in the "Decoudun" type) to eight or nine. In Fig. 1 is shown a six-roller Tullis ironing machine in service. It consists essentially of strong cast-iron cheeks, upon which are built the steam-heated beds, rollers, gearing and guards, which together do the work of ironing and drying the goods as they are passed through the machine. Fig. 2 shows a Tullis two-roller starchwork ironer. Its constituent parts are essentially similar to that of the machine shown in Fig. 1, the difference lying mainly in the size and shape of the beds and rollers. The cheek castings present no serious difficulties and call for no comment. The problems associated with the making of cast gears and gear blanks have been discussed by the author in other Papers. The castings which present the greatest difficulty to the foundryman in these machines are the beds. These are made in varying sizes and shapes; the one thing common to them all being that each is a steam-tight chest, one (hollow) surface of which must be a flawless polished surface. Fig. 3 shows a 24-in. by 120 in. (Decoudun type) bed, with the polished, working face down. This bed will be used here to illustrate the general problem. Fig. 4 shows a cross-section of the bed, and a longitudinal section (smaller scale). The casting as it leaves the foundry weighs nearly 33 cwts.

The operating surface of this ironer bed has a machined and highly-polished surface of nearly 32 sq. ft., which is cast down. Though the working steam pressure is only in the region of 100 lbs. per sq. in., these castings must be classed as high-duty castings. They are expected to give satisfactory service for a period of upwards of 20 years. This means that they must not distort or lose much of their mechanical strength in service. Further, these castings are subjected to repeated heatings to temperatures approaching 200 deg. C. each working day, and cooling during each night. Every article passed through the machine abstracts heat from the operating face of the casting locally. It has been estimated that some 30 per cent. of the weight of the articles, prior to passing under the rollers, is water. The sudden and repeated local application of wet cloth on the surface of the bed sets up continual stresses and strains in the casting, owing to varying contractions and expansions.

A metal suitable for this work must have certain definite qualities. It must be of high tensile strength, highly rigid and yet capable of "breathing" without fracture. It must show the minimum growth of graphite (consequent upon the breaking-down of combined carbon) on long-continued heating and cooling to and from 200 deg. C. over long periods of time; for a reduction in the proportion of combined carbon in a casting results in a serious reduction in mechanical strength, and also in growth or distortion.

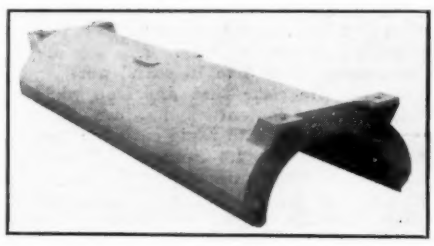


FIG. 3.—A 24 IN. × 120 IN. DECOUDUN BED.

A good deal of work has been done upon this subject during the last 25 years by various investigators, but probably the most helpful in this particular connection has been that of Campion and Donaldson. In a Paper* read to the Lancashire Branch of the Institute in 1926, Dr. Donaldson gave the results of a very comprehensive series of experiments, and he arrived at conclusions which confirm and simplify the results of other investigators. He showed that decomposition of carbide in grey iron takes place at temperatures as low as 200 deg. C. (it certainly takes place at even lower temperatures), that the extent of the decomposition depends upon the amount of the silicon content, being more pronounced the greater the quantity, and that it also depends upon the temperature and duration of the heat-treatment. He further found that there exists a critical condition at round about 1 per cent. silicon, at which carbide decomposition is at a minimum. Any higher silicon proportion results in a more rapid decomposition. Dr. Donaldson's conclusions considerably narrow the search for a suitable grey iron for the purposes here under consideration. Irons of high silicon content are clearly quite unsuitable, even when, as in the case of the Thyssen Emmel iron, it is associated with low total-carbon. Irons of this order have a total carbon content of from 2.4 to 2.8 per cent. together with a silicon content of 2 or more per cent. In the course of the discussion following the reading of the Paper referred to above, Dr. Donaldson pointed out that he had carried out a test with an iron containing 1.78 per cent. silicon and 2.75 total carbon, and that after 200 hrs.' treatment at 550 deg. C. the carbide decomposed to the extent of 48 per cent.

In some results published by Campion and Donaldson in 1922,† an iron which had been heat-treated, containing a total carbon of 2.8, gave no more resistance to growth than irons with 3.3 per cent. The reasonable conclusion is that irons with high silicon contents, even when associated with low total carbon, must rapidly lose some of their initial strength on repeated heating and cooling, and that the rate of that loss of strength is very much greater than in the case of irons having low silicon content. With the loss of strength due to carbide decomposition there is always associated growth, and where that growth is uneven there follows distortion. Though the carbide decomposition in an ironer bed must be very slow, it should be remembered that, in five years' time,

* A Paper read before the Edinburgh Section of the Institute of British Foundrymen, Mr. W. Wallace presiding.

* Proceedings, I.B.F., Vol. xx, 1926-7, p. 513.
† Proceedings, I.B.F., Vol. xv, 1921-22, p. 211.

it will have been heated for 8 hrs. each day and cooled during the night some 1,400 times. In this connection the microphotograph shown at Fig. 5 has interest. It was taken from a piece of an old ironer bed which had been in service for 28 years. From its composition, it probably had an original carbide content of about 0.5 per cent., together with a silicon content of 2.0 per cent. As will be seen, the combined carbon has almost entirely broken down, the structure consisting almost entirely of ferrite, temper carbon and graphite.

An iron in or approaching this condition has lost a good deal of its rigidity and mechanical strength and is likely to distort or fracture under comparatively light loading.

In the Paper* read by Campion and Donaldson in 1922 a good deal of light was thrown upon the influence of manganese. They proved that this element exercises a powerful influence in retarding growth on repeated heatings and coolings. But they also showed that manganese, in proportions above 1 per cent., induces an actual shrinkage in volume after a few heatings and coolings to and from 500 deg. C. Donaldson also noticed the same phenomenon in the case of chromium additions to cast iron. What influence these elements have in the case of repeated heatings and coolings to and from temperatures no higher than 200 deg. C. is at present unknown. That they will help to maintain unimpaired the mechanical strength is indubitable. On the other hand, in a case such as an ironer bed where heating (owing to service conditions) is uneven, and where an important consideration is absence of distortion, a tendency to uneven shrinkage in size might give results as unsatisfactory as those due to growth. The writer therefore concludes that, in the light of present knowledge, a manganese content of about 0.8 per cent. would appear to offer the maximum advantage for work such as is here being considered, whilst additions of chromium would be of doubtful utility.

In view of these considerations, the iron used for the bed shown in Figs. 3 and 4 has a composition of the order of silicon 1.0; combined carbon 0.8; graphite carbon 2.4; manganese 0.8; phosphorus 0.3, and sulphur 0.1 per cent. Such an iron has a high resistance to carbide decomposition and a tensile strength averaging 17 tons per sq. in. cast in a test bar 1⅛ in. dia. and machining down to 0.798 in. dia. The metal leaves the cupola at a temperature in the region of 1,400 deg. C., and the moulds are cast at round about 1,330 to 1,350 deg. C. The metal is made up of Scottish hematites and steel. It is highly fluid at the temperatures used, giving a close-grained and entirely satisfactory metal.

The microphotograph at Fig. 6 shows the structure of this metal taken from a test-bar cast at 1⅛ in. diameter. It represents a magnification of 500 diameters. The microstructure, which is of fine pearlite and sorbite, indicates considerable strength. The tensile strength of this metal is probably equal to what can be attained in day to day workshop practice, where Thyssen Emmel iron is in regular use (one British licensee states that strength at 14-20 tons per sq. in.), and without the disadvantages resulting from high silicon contents.

In service the beds rest at each end on flanges on the cheeks, and are stressed in much the same way as is a test-bar under transverse loading. The load is not of a high order, being in the region of half a ton distributed more or less evenly, by the roller, along its length. To this must be added the gravitational pull of the bed's own weight. The loading is intermittent and repeated, and takes place when the bed is at a temperature approaching 200 deg. C. If the metal is of a quality which, being high in silicon content, is predisposed to carbide decomposition and tends to become ferritic, it will tend to extend under repeated loading on the side of the bed which is put in tension, *i.e.*, the under side. This results in a slight sag in the middle of the bed, which, though only in the region of a few thousandths of an inch, militates against maximum efficiency. This sag may become evident after 5 to 10 years' work. It is therefore quite clear that any iron which has a high silicon content, and which is, consequently, predisposed to rapid carbide decomposition, is not suitable for work of this character. The practice of the author's firm is to cast these beds in a metal which has a high degree of carbide stability, ensuring maximum strength over many years of service. This is supplemented mechanically by the provision, at the centre of each bed, of a support which is adjusted to take up the full load. Consequently the possibility of sag is reduced to the barest minimum.

The moulds for these castings are rammed up from a pattern in dry sand. The sand used has, as a base, Scottish rock sand. The moulding calls for no special mention, except that nothing less than first-class workmanship is good enough. Very careful ramming and finishing of the mould is imperative, for a mould or core scab will give an unsatisfactory casting. It is essential that the mould should be thoroughly dried, firstly because of the need for avoidance of scabs and, secondly, so that there shall be no water vapour in the mould prior to casting.

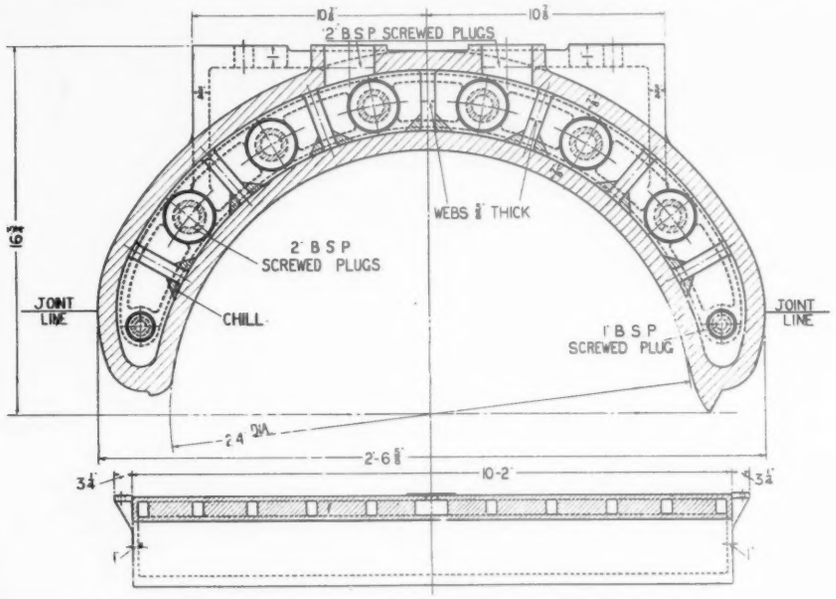


Fig. 4.—Cross Section of Decoudun-Type Bed weighing 33 cwts.

Fig. 5.—Photomicrograph of a very old Ironer Bed taken at the Cross Section of a patch after 28 years in service. × 800 dias. The Combined Carbon is 0.14 per cent.

The core for a casting of this character is a serious proposition. A view of a core for a smaller bed than the one under consideration is seen hanging from the crane in Fig. 7. The construction of the core for the bed shown at Fig. 4 is similar. As will be seen, it is just a shell, 2¾ in. thickness, tapering down at the ends of the horns. Through the core, joining up the inner and outer walls, are 70 webs, varying from 6 to 9 in. long, but only a few of them are of the shorter length. These break up the continuity of the core mass. The ironwork of the core consists of light iron bridges threaded on six steel tubes. The tubes have an inside diameter of 1 in. and an outside diameter of

Fig. 6.—Photomicrograph of Iron now Used for Bed Castings. × 500.

* Proceedings, I.B.F., Vol. xv, 1921-22, p. 211.

1½ in. These tubes are drilled along their length every six inches for venting, and serve that purpose adequately, with the aid of a series of wax vents in the region of the horns of the core. The core is made by strickle, being struck up directly upon a cast-iron plate giving the exact contour of the hollow side of the core. The sand is an oil sand, which has obvious advantages; the first being its ready venting qualities, and, secondly, ease of extraction from the casting. In castings of this character it is important that

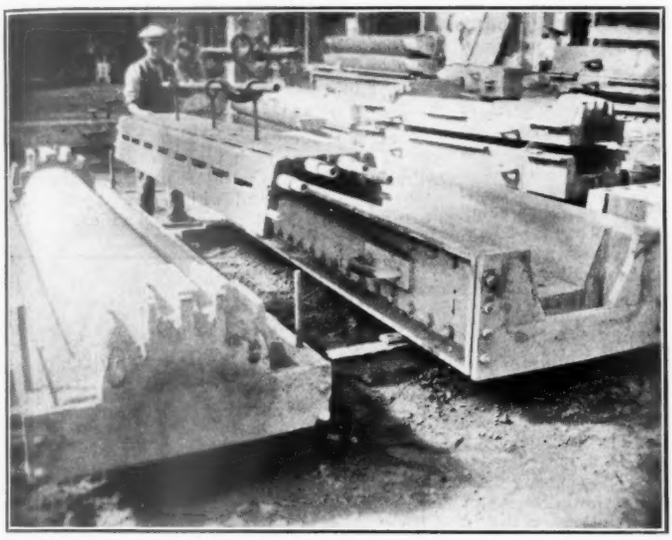


Fig. 7.—Mould and Core for an 18 in. × 120 in. Ironer Bed.

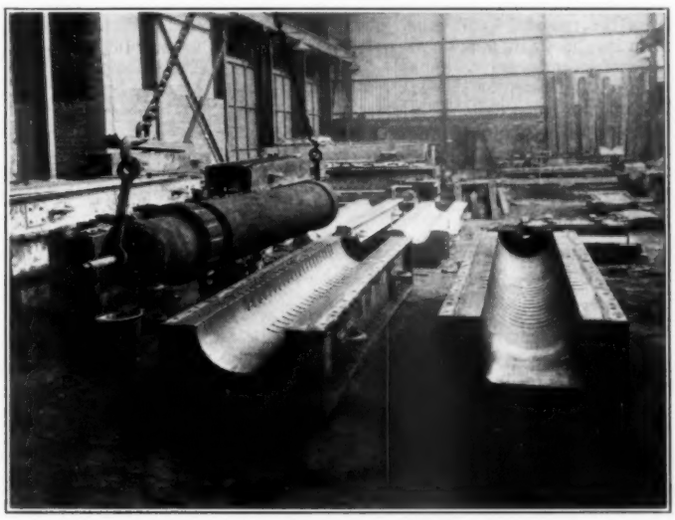


Fig. 12A.—Mould and Core for a 24 in. × 120 in. Ventilated Roller.

no sand should be left in them. It is not difficult to visualise the difficulty which there would be to get out of the casting a core made in ordinary core sand, and there would never, having regard to the many webs inside the casting, be any assurance that all the core had been taken out.

The sand in use is Irvine sea sand, which has proved highly satisfactory in use. The oil used is of the thin fluid type, the ratio of oil to sand being 1:20. This sand mixture, all along the extremities of the horns of the core, has an additional bond constituent of 1 per cent. of core gum. It is along this part of the core that the metal races as it fills up the mould. Where, in any core, the bond burns out too soon, the core tends to disintegrate, and sand will be found in the casting where it is not wanted. Consequently, such portions of an important core as are subjected to long continued impingement by the molten metal should have an excess, or a reserve, of binding material.

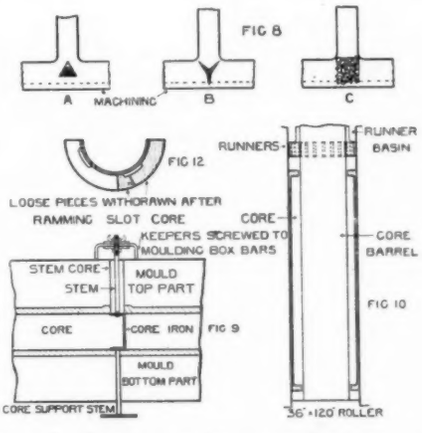
A burnt or underbaked core is useless for a job of this character. A temperature of 200 deg. C. should never be exceeded in the stove. A properly baked core is easily checked. Its finished colour should be nut-brown. The touch of a finger-nail will break the surface of a core which has been over-baked. Such a core as is now being considered should be examined all over its surface prior to blacking, for it may be burnt locally.

It has been pointed out that there are 70 webs joining the two walls of the casting. Every foundryman will at once realise that these provide at least 70 possibilities of porosity on the machined inner face of the casting. Further, apart from the question of steam-tightness, it is necessary that there should be no places showing an open structure, which would seriously diminish the capacity of the bed to give a good finish to the articles put through the machine in service. Consequently, the fillet of every web is chilled along its whole length, on both sides of the web, where it joins the working face of the casting, as is shown in Fig. 4.

Shrinkage Phenomena.

A few general observations may not be out of place here. Cast iron, in common with most other metals, shrinks in volume in crystallising from the liquid to the solid. As the outer shell of metal in contact with the mould and core surfaces freezes first, the total net shrinkage usually appears in the inner portions of metal, particularly wherever there is a local increase in section, due to the joining up of walls, the presence of bosses or similar additions to bulk. The freezing shell takes the form and size of the mould, and, consequently, the shrinkage in volume due to crystallisation often results in the presence, somewhere in the heart of the casting, of a cavity or cavities. Or it may make its presence felt, in a more widely distributed form, as porosity or even structure. These forms of cavity are illustrated in Fig. 8. Of course, these cavities never appear as regular figures as shown in the sketches, but they will serve to illustrate the tendencies at work.

The sketches are intended to show three similar sections in which, depended mainly on metal



Figs. 8, 9, 10 and 12 show Defects and Moulding Details connected with Laundry Machinery Castings.

composition, the same amount of cavity will be distributed in a different way. In the case of "A" the cavity lies hidden and may be quite harmless in regard to the efficiency of the casting of which it forms a part. In the case of "B" the defective nature of the cavity is a very serious matter, but local. The case of "C" is hopeless, for nothing at all can be done with a widespread spongy area. It is perhaps unwise to generalise, but there are sufficient grounds for thinking that the defect at "A" is representative of grey irons, the composition of which makes for a short freezing range (the strong irons), that at "C" of those with a long freezing range (the weak irons), while "B" represents the intermediate type.

In the case of "A," freezing probably takes place as a more or less level thrust of dendrites from the outside of the metal section to the middle, building up solid behind from the available mother liquor—for as long as the supply lasts. When that fails a fairly regularly shaped cavity will appear. In the case of "C," long pioneer dendrites grow out, with the result that a final lack of mother liquor is manifested in widely-distributed small voids or porosity, which connect one surface of the section with another. The case of "B" is again intermediate. Observation shows (and commonsense assures it) that those portions of a casting which freeze first are those which are thinnest or farthest from the runner, and those portions will always be found quite sound, as far as shrinkage cavities are concerned. The obvious inference (and observation demonstrates it) is that the thin portions make up their loss of solid volume at the expense of neighbouring heavy sections, or of sections which, for one reason or another, hold metal which is still liquid enough to flow—in accordance with the law of gravity. Now these observations are true of all grades of grey iron, even when metallic additions are made (*e.g.*, nickel) or of the low total carbon irons of the Thyssen Emmel type.

The metal compositions which have the shorter freezing range are those low in carbon, silicon, and phosphorus, but, whilst such irons will always show greater soundness (other things being equal) their solid volume will be less than their liquid volume and, in the absence of provision for a supply of new liquid to make good the loss of volume, cavity in some form will occur. A good deal of that loss, however, is made up naturally. No casting freezes instantaneously. Freezing takes place in accordance with the heat gradient set up in the mould by the path of the metal during pouring; and a good deal of the crystallisation shrinkage is made good from the runner and from heavy risers. But isolated bosses, wall junctions, and other heavy sections cannot get their quota of new liquid in this way. The "chill" can be so used as to provide a solution. It should be of such a weight as to make for solidification of the heavy portion before the surrounding thin portion.

But, it may be said, will not the heavy section then rob the thin? In such circumstances the thick portion will not rob the thin, for the thin places will have their losses made good from the runner, or other head of metal. Take a shank of iron and cast out of it (1) a 5-in. cube and (2) a plate $\frac{3}{8}$ in. thickness, both having the same cubic capacity. Assuming proper moulding conditions the plate will be found to be quite free from defects, but the cube will show cavity. Why is this? The plate will freeze quickly and the crystallisation shrinkage will be made up automatically, along the line of the heat gradient from the runner. The cube, longer in freezing, finds its supply of new liquid cut off, with consequent residual cavity.

To return now to the particular case of the ironer bed, reference to Fig. 4 shows that a chill is laid along each side of each web where it joins the operating face of the casting. There are 140 such chills in each core. In each chill a series of sprigs is cast; the sprigs being bent round the core barrels to ensure stability. Before laying in place in the core, each is wiped with sperm oil, and another wipe of sperm oil is given the chill when the core is ready to place in the mould.

There is a point of interest to note here: Observation shows that a chill which is long as compared with its cross-section, and which comes into contact with the molten metal on one of

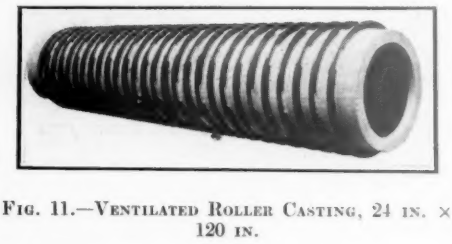


Fig. 11.—Ventilated Roller Casting, 24 in. × 120 in.

its faces, tends to camber. Trouble will arise from this where it occurs, but no trouble of this character arises even when these chills are used up to 16 in. long. The reason is that the cross-sectional area of the chill is small, being a right-angled triangle having a length of $\frac{3}{4}$ in. on each side of the right angle, less the round fillet. In such a small cross-section the heat transmission is sufficiently rapid to prevent camber of the chill.

No chaplets are used anywhere in this casting. The core is seated in six $1\frac{3}{4}$ in. round core prints at each end (these holes being later plugged). Two 2-in. holes on the back of the casting provide the remaining anchorage. This is illustrated in the sketch at Fig. 9. A hole is made in the centre of the bed mould in the drag, and before the core is lowered into the mould a pin is passed through it, resting on an iron plate on the floor. The pin is clearly seen sticking up through the drag at Fig. 7, which is a photograph of a mould and core of a smaller bed (18 in. by 120 in. of a different design). The pin stands up above the surface of the mould the exact thickness of the metal required. A bridge iron in the core carries two lugs, the bottom one of which rests on the pin, thus supporting the core. When the top part is put on, two $\frac{3}{4}$-in. screws are passed through the 2-in. holes in the top part, and screwed into the upper lugs in the core bridge.

A suitable 2-in. core is then slipped down round the screws, thus filling up the print, and ensuring that the screw is kept clear of the metal. The holes in the top part are then rammed up with sand. The screws project above the top part past the keepers shown in the sketch, and thumbscrews above the keepers take up the weight of the core, ensuring the exact thickness of the metal below the core. Also, as will be seen in the sketch, nuts on the underside of the keepers effectively hold the core in place against the displacement lift of the metal. The pin in the drag which had been supporting the core is then taken away and the hole sealed.

The moulds are cast "on the bank," at an angle to the shop floor of about 20 deg. The runners are at the top end, giving entry to the mould at the bottom of each horn.

Roller Making.

Another important part of an ironing machine is the roller, of which there may be as many as eight or nine on a machine. They need to be perfectly clean and well balanced. They are made in various sizes, up to 120 in. in length, and of diameters from 9 to 48 in. Plain rollers up to 15 in. dia. are rammed up from patterns. The bigger diameter rollers are strickled up in loam. These moulds up to 36 in. dia. are made in boxes which enable the mould to be split in half, longitudinally. The joint edges of the moulding boxes are machined and the mould is struck out with a semi-circle strickle. The mould for this type of roller is always a simple cylinder, the internal flanges of the roller being swept up in the core. The cores up to 36 in. dia. are all struck up on trestles, the core barrels for the smaller diameters being of steel, and those for the larger diameters of cast iron.

This type of roller does not call for much comment. A line section view of a 36-in. roller mould and core is shown in the sketch in Fig. 10. The method of running is indicated in the sketch. The runners are all 1 in. by $\frac{1}{4}$ in. in cross-section, and the same kind of runner is used for all rollers. They are rubbed in the core at the top core-seating, and are placed at intervals of about 4 in. all round the circumference. These runners have proved highly satisfactory for all sizes of rollers. Their nearness to each other results in the metal, when rising in the mould, being kept in constant agitation at its surface, and drosses are brought up safely into the head. These rollers are machined all along their length, and most of them are required to stand up to a working pressure up to 100 lbs. of steam. The chief defect to guard against in a casting of this character is the blow hole, found on machining. The cast thickness for some of the smaller rollers is $\frac{7}{16}$ in., though the larger ones run up to 1 in. It is not an easy matter to get 10 ft. of a thin casting absolutely free from blemish on machining and test, but, with care and forethought, highly satisfactory results may be obtained. The chief conditions for success are (1) a properly-rammed and dried mould and (2) a good core, well dried but with no burnt hay-bands—the last two layers of hayband leaving at least an inch between each band. A further important condition is that there shall be left no wet or damp luting between the bottom end of the core and the mould. Where loam stamps are used on an important casting to seal up the flash round a cylinder core of any kind, the stamps should be thoroughly dried before the top part is put on. It is futile and stupid to depend upon the hot mould to dry a stamp. Where that is done there will be a trail of grief in the shape of a group of mysterious blowholes not far away from the region of the stamp.

Another type of roller, having a little more difficulty, is shown in Fig. 11. All the general remarks above apply equally to this type of roller, which is cast on end in the same way. An important thing to control, in a casting of this character, is that after pouring it should be as free as possible to contract. This cuts out the use of gaggers in the top half of the mould, as rammed up. The mould is, of course, dried, and a double row of 6-in. sprigs is found quite sufficient to carry the outstanding sand between the gills. Soon after pouring, the box with the casting is lifted out of the pit and the bolts are taken out at the joint.

It will be noticed that each gill of this casting has four slots cast in it, their purpose being to allow of easy evacuation of water vapour, which is generated in service from the goods passing through the machine. If these holes were formed by loose dry-sand cores, the result would be a not very good job, leaving a lot of unnecessary work for the fettler to do. In the casting shown in the illustration there are 92 such slots. They are made very simply. On the pattern there are no core prints for these holes. The gills are plain flanges, and are finished in the mould as such. Two small making-up pieces are then inserted in the gill, as shown in Fig. 12, sand is rammed into the space which is to be the slot, sprigged and vented, scraped and sleaked level and the loose pieces withdrawn. This makes a sound job, binding up the sand between the gills, from one end of the roller to the other. A view of a mould and core is shown in Fig. 12A. The right-hand half-mould is unfinished, the ventilation slots not having been rammed in.

Metal Characteristics.

The metal for castings of this character need not be of a very high tensile order. Any plain cylinder, which has no attachments in the shape of brackets, etc., and which is cast on end, is likely to be perfectly sound when cast with a

Fig. 13.—Tullis Pneumatic Press.

relatively soft iron mixture which will facilitate machining operations. For the thinner rollers a metal having a silicon content of round about 2.3 per cent. is quite satisfactory, and, in the heavier rollers, a silicon content of about 1.75 per cent.

(To be concluded.)

Deoxidation of Steel.—In the course of a Paper read recently by Mr. John Chipman before the American Society for Steel Treating, on the "Application of Thermodynamics to the Deoxidation of Liquid Steel," methods by which thermodynamics may be applied to the study of reactions in liquid steel are briefly reviewed. Experimental evidence is presented to show that the oxygen in liquid steel is present in the form of a dissolved oxide whose molecule contains one atom of oxygen. This oxide is considered to be FeO. The free energy and activity of this oxide in liquid steel are computed from the equilibrium data involving steam and hydrogen. Additional evidence is presented to show that at low percentages carbon is present in austenite and in liquid iron mainly as Fe_3C. Thermodynamically-calculated equilibrium constants involving this carbide, FeO, CO and CO_2, are in fair agreement with the experimental results of Vacher and Hamilton. The free energies of a number of metals (dissolved in liquid steel) and of their oxides are obtained from various types of thermodynamic data and the results are used to compute the equilibrium constants in the reactions by which dissolved FeO is removed from the steel bath by the respective metals. From these equilibrium constants the deoxidising powers of the alloys are computed. The metals under consideration are the following, arranged in order of increasing deoxidising power at 1,600 deg. C.: Chromium, manganese, silicon, titanium, vanadium, zirconium, aluminium, magnesium, and calcium.

Education of Foundry Executives.

THE PROPOSED DEGREE COURSE AT SHEFFIELD.

Dr. J. H. Andrew, Professor of Metallurgy at Sheffield University, presented a convincing case for the inauguration of a degree course in founding at Sheffield, when he addressed the Birmingham, Coventry and West Midlands Branch of the Institute of British Foundrymen on "The Education of Foundry Workers." The meeting was held on November 2, at the James Watt Memorial Institute, Birmingham, Mr. E. J. Lewis (Branch-President) in the chair.

The CHAIRMAN, introducing Prof. Andrew, said the proposed University course did not mean that foundrymen needed training in elementary matters. It was recognised, however, that their efficiency would be increased by greater scientific knowledge and a closer acquaintance with scientific methods. The lecturer was the originator of the scheme for establishing a Foundry course at Sheffield, which was sponsored by the I.B.F. He (Mr. Lewis) appealed for enthusiastic support of the project.

PROF. ANDREW said the intention was to institute a course in foundry training which would culminate in the degree of Bachelor of Metallurgy (Founding). In the past the foundryman had not received as much attention as was essential or as he merited. His opinion was that the foundryman had intelligence and a mentality equal, if not greater, than that of any other metallurgical worker, and the present scheme aimed at giving the foundryman what was only his right.

Outlining the proposals, PROF. ANDREW said they were, of course, based on the wants of the foundryman. The number of castings cast direct from the blast furnace was limited. Therefore matters concerned with blast-furnace practice could be very largely curtailed. Instead, they would have to deal with matters appertaining to the use of furnaces of many different types. In the foundry they now used oil furnaces, electric furnaces, small Bessemer furnaces and various types of furnaces of much smaller capacity than were used for casting large armour plates or ingots for large forgings. Consideration of these smaller units was bound to be omitted from any general metallurgical course, but those concerned principally with iron and steel founding required that there should be adequate treatment of such furnaces. He wanted to emphasise that the course was not confined to iron and steel founding, but also took into account non-ferrous founding and practice. The methods employed for non-ferrous founding had advanced very considerably, and differed largely from those in the iron and steel foundry. An important feature of foundry practice, which was not dealt with at all in the usual metallurgical course had reference to the use and testing of moulding sands and core sands, the actual making of moulds and cores, the supporting of the latter and venting of both. But in foundry practice these subjects formed a large and important section, requiring not only many lectures but a long time spent in the laboratory. It must be realised that in the university laboratory it was possible to try out things in a way that was impossible in the works themselves. They would make up particular moulds and cores which they knew would result in bad castings; they could maltreat their castings; they could cast in incorrect as well as correct temperatures, knowing that one learnt almost as much from purposely bad practice as from good practice. Another important question was that of testing sands. Many foundries had appliances for sand testing, but a university should be equipped with all the latest devices and help to train students in the testing of sands so that when he got to the works he would be *au fait* with all the methods employed, and was capable in every respect of testing sand. A further subject omitted from the general metallurgical course was patternmaking. He considered a student should be fairly competent not only to design his patterns but actually to make the patterns in the university shops. He should become sufficiently acquainted with the art of patternmaking to make the necessary allowances and avoid the troubles that often arose from a bad design. Recently mechanisation had loomed very large in foundry practice, and coremaking machines, sand-mixing machines and particular furnace designs should be dealt with by lectures, and, as far as possible, by actual practical training in the university laboratories. The question of casting temperature was very important. The student should be made to cast metals—iron and steel and various non-ferrous metals—at widely different temperatures, discovering the temperatures which gave the best results and those giving less satisfactory results. In the casting of ordinary carbon steel, as compared with alloy steel, different casting temperatures, different rates of pouring and probably different methods of moulding were necessary. The student could experiment on all these in the laboratory, whereas in the works he simply carried out the methods found to be the best practice. If he had the means of carrying out varying tests he might find out better methods than were at present employed.

Less Analytical Work.

The question of chemical analysis also came in. The ordinary metallurgical student had to undertake a fairly-wide course of chemical analysis. In the foundry, chemical analysis was usually done by the works chemist, and it was becoming less necessary than ever for the foundry metallurgist to have a complete knowledge of chemical analysis. It was, therefore, possible to omit a large amount of time at present spent on chemical analysis. Lastly, he wished to refer to metallography. The student going to the foundry would want to specialise in the examination of castings, and find the effect of heat-treatment on castings. He (Prof. Andrew) had recently examined one or two large steel ingots. In a 170-ton ingot there were about fifteen different structures. They would therefore realise that there was a great deal of work to be done in the examination of castings. When they cast a complicated casting in the works they had to fettle and despatch it. When, however, they cast it in the laboratory they could section each piece, they could take sections of small diameter and sections of large diameter, examine them and find the differences of structure. It might be possible to give them treatment which would make them all homogeneous.

A New Study.

He did not think it could really be definitely said that we knew of a treatment which would give a homogeneous casting. And so the student not only studied the various types of casting, after making them himself, but became an investigator, because he was undertaking what was entirely new work. He (Prof. Andrew) would almost go the length of saying that the subject of castings had never been examined with the thoroughness that forged and rolled sections had received, so that in entering on the study of foundry operations they were conducting more or less a new investigation. Further, the student who undertook a foundry course of the type he had indicated would be valuable to the foundry when he had passed through his course, because not only would he have learnt what was already known, but he would take into the foundry new knowledge and help in the improvement of the castings of the future.

Sandwich Course.

It was true, of course, that no student could learn actual foundry practice in a University laboratory. It was necessary that he should learn actual practice in the works and that he should co-operate sincerely with the wonderful practical men in the foundries. In his view the practical side should be undertaken not merely after, but during the University course. With that in view, it was suggested that the course at Sheffield, if it came about, and he was determined that it should come about, should be more or less a sandwich course.

Covering a Wide Range.

In his first year the student would learn the fundamentals—physics, chemistry and mathematics—and in the second, third and fourth years he would spend the first two terms at the University and the third term, and a large part of the long summer vacation, in the foundry. If he wanted general foundry practice, he (Prof. Andrew) suggested that the first year should be spent in an iron foundry, the second in a steel foundry and the third in a non-ferrous foundry. On the other hand, if the student desired to specialise in iron founding, he might spend the first year in a simple foundry, the second in a mechanised foundry and the third in a foundry according to his own choice. He felt that if the course came into being there would be wonderful co-operation between the University and the foundries in turning out a thoroughly sound, trained man capable of dealing with the many problems of the foundry.

Why Foundry Degrees should be Granted.

Prof. Andrew quoted the opinion expressed in an article in a metallurgical Paper that "to go to the length of offering a University degree in founding would seem to us to be nothing less than inviting ridicule upon technical University degrees in general." He took it that the writer of the article was in favour of having one degree for all Science—a B.Sc. degree—and suggested that it would be ridiculous to attach to that degree any particular significance, such as founding. He (Dr. Andrew) thought that idea was wrong. He pointed out that the medical profession differentiated between various branches of study, and asked why the metallurgist should not follow that example. Metallurgy was now a science of the first order, but it was a science to itself, and he did not think that it ought to be associated with a general science course such as was taken by pure chemists or pure physicists. Why should not they follow the example of the medical profession and give a degree which showed the public that a man had definitely studied metallurgy, and further, that he had definitely studied metallurgy, specialising in the art of founding? He believed that such a step would be distinctly in the right direction. Moreover, it would raise the status of the foundryman to a level which at present did not exist. He had noticed a keenness among foundrymen such as he had never seen in any other metallurgical profession, and he was convinced that if only the trade would give the scheme its support they would never look back. It was no use carrying on, as they had in the past, by more or less empirical or rule-of-thumb methods.

Answering the question "Why should the Institute of British Foundrymen support the Sheffield scheme apart from any others?" the lecturer said he thought he could claim the credit of being the first to suggest a course of specialised foundry training. Then, at Sheffield, they had a degree of Bachelor of Metallurgy, on to which it was easier to attach founding than to the ordinary B.Sc. degree. Thirdly, they had already a very considerable amount of foundry plant, more than a nucleus, and were ready to start the foundry course next session if adequate financial assistance was forthcoming. All they asked for

was about £1,200 per annum, which, distributed over the 6,000 or 7,000 foundries in the country, would not be felt to any appreciable extent. He thought the foundry industry employed a far greater number of hands than any other metallurgical industry in the country.

Where the University Helps.

Prof. Andrew made it clear that they intended to make provision for the poorer foundryman who could not afford the high fees necessary for the degree course, and commenting on foreign competition he said that while this country made as sound castings as any other country, he understood that certain alloy castings were bought from abroad. He could only attribute this to the fact that most of the other countries, and in particular France, Germany and America, had already excellent foundry courses. One of the reasons why they could make some of these special alloy iron castings, and we could not, was because their men had a better training, the casting of such materials requiring not merely a rudimentary knowledge but some rather expert knowledge. He did not want it to be thought that they imagined that in a University a man could learn everything. He could not. But the University turned a man out with a trained mind and created in him a faculty of imagination, and he believed that what were wanted to-day were men of enterprise and imagination, who would not be content to carry on as in the past, but would always be intent on obtaining better results than formerly.

The lecturer showed a number of slides illustrating the lines along which they were developing at Sheffield and which he said made it apparent that they already possessed rather more than a nucleus of plant for giving foundry instruction. They also had the greater part of the necessary staff and they had enthusiasm on the part of the staff. All they wanted now was for the industry to back their project and to tell them to go ahead.

The Chairman said Sheffield appeared to have all the apparatus necessary for the scheme to be carried into effect, and it only remained to raise the necessary funds.

Specialisation Commended.

Prof. D. Hanson, in proposing a vote of thanks to Dr. Andrew for his presence and address, said that enthusiasm was an even greater asset than money, and if anything could carry the scheme to success it was the enthusiasm of Prof. Andrew. Discussing the general question of the advisability of instituting courses of training for technical workers, Prof. Hanson mentioned that at Birmingham University they had courses in metallurgy, courses for miners and oil engineers, and even a School of Brewing. Throughout the whole country there were these applied science courses at which some of the so-called pure scientists occasionally sneered. In his opinion training in applied science was, as a rule, a much broader education than training in pure physics or chemistry. In former years it was quite natural that a man should read science without specifying exactly what that was, because the advances made by science were not too great for a man to specialise in.

Nowadays, however, a huge number of subjects was covered by the degree of Bachelor of Science. In fact, it was now necessary to divide learning into trade and professions, and science was not going to be much use unless one could apply it to improving the standard of living and making things possible that otherwise would be impossible. Why should not there be a course in which science was applied to foundry materials and all the things that went to the casting of metals? It was a perfectly reasonable thing to do. The only thing to be guarded against was to see that it did not become the sort of course which was not a scientific course, and no such fear need be entertained so long as Prof. Andrew was at the head of affairs.

Physical Chemistry an Essential.

It was essential that the aim of the course should be to apply to founding all the necessary branches of science, which included physics and chemistry, and particularly physical chemistry, as well as the subject now known as metallurgy. He suggested to Prof. Andrew that plenty of physics, plenty of chemistry, and especially physical chemistry, should be an essential part of the training, because there were certain aspects of founding which would only be understood and solved by the application of those processes. Take the question of the soundness of castings. The reactions which led to the absorption and evolution of gas from molten metals could only be understood by the application of the laws of physical chemistry. They were quite certain of that. The laws were very intricate and needed men with a great deal of knowledge and training to understand and apply them, particularly when they must be studied at high temperatures which would make the man in the street stare. He appealed for as much widening of the course as possible in the subsidiary subjects. For example, he did not consider that any foundry worker would be properly equipped without a little knowledge, at any rate, of electrical engineering, as well as of refractories and so on. The course should include all the auxiliaries necessary if foundry specialists were to be turned out equipped to handle all branches of their subject. Run on the lines indicated, he was convinced that the project would be an amazing success. He hoped that those in control of foundries would support the scheme and find whatever funds were necessary to start it. It was even more important that they should support the scheme by taking the men into the foundries when they were trained.

Mr. W. J. Molineux, in seconding the motion, said that Huxley had described science as organised common sense. As regarded foundry practice, it would be agreed that they had common sense, but they lacked the organisation. If he had understood Prof. Andrew, that was what he was out to correct. They all knew only too well, and especially those who had been in the foundry for a considerable time, that if they went into the foundry and asked anyone in control a question regarding difficulties in connection with founding, they very often got an expression of opinion, when they should receive a statement of fact. If a man who had been trained in pure science went into the foundry, he was usually very largely lost so far as helping the founder in the production of good castings was concerned. It was equally true that if the average moulder or foundryman went to the University, he would be completely lost when they talked to him of metallography and other branches of science. He presumed that it was the co-ordination of the severely practical side with the scientific side that they were striving to bring about, and they were all absolutely in agreement that it should be done. They might differ as to the methods, but there was not the slightest doubt that it must be done. He, for one, would give the scheme his whole-hearted support, and he thought the members of the Branch generally felt as he did.

The vote of thanks was heartily accorded.

LECTURER'S REPLY.

Returning thanks, Prof. Andrew said it meant a great deal to him that one of his fellow-professors had the welfare of the scheme so much at heart. He informed Prof. Hanson that the course included two years' study of physical chemistry. He agreed that scientific knowledge was applied common sense, but said it was necessary to reach a certain height in scientific attainment before the common sense could be attained. We were living in an age of specialists, and while it should not be attempted too early on, the young men must eventually become specialists, because metallurgy had grown so enormously that it was impossible for one man to carry in his head all the metallurgical knowledge existing to-day. It was even impossible to keep up with current literature. A man had to be more or less acquainted with everything and specialise in a certain operation.

In the course of the subsequent discussion, Mr. F. C. Edwards urged that the existence of a degree course would raise the status of the industry. He spoke of the opportunities which foundry work presented for men of the highest mental attainment, and added that what the foundry trade needed was men of enterprise and imagination.

Mr. G. T. Lunt said he considered the Birmingham Branch was to be congratulated on securing Prof. Andrew to read this Paper, and he felt that he, and everyone present, were assisting in the making of history. Prof. Andrew had made reference to an article which he himself had not read. It would appear from this article that the writer considered that the foundry trade was not of sufficient importance, or not sufficiently scientific, to be worthy of a degree course in foundry science. He thought, and he was sure that everyone present thought, that the foundry trade was big enough and important enough to be worthy of such a course.

Birmingham Support.

Mr. D. H. Wood added his tribute of praise to Prof. Andrew, and considered that his scheme should have the support of everyone interested in foundry work. The present, he thought, was a very opportune time for such a scheme, as the old craftsmen were gradually dying out and should be replaced by the scientifically-trained worker. He proposed a resolution that the Birmingham, Coventry and West Midlands Branch give their wholehearted support to Prof. Andrew and his scheme, and do all in their power to assist in making it a success.

Mr. G. M. Callaghan seconded the motion. He knew the difficulty there was in getting the necessary scientific knowledge in the past, he said, and he considered it imperative that it should be possible to obtain theoretical and practical knowledge of foundry work.

Mr. A. Tipper said that he understood that the qualifications necessary for the degree would be first of all matriculation, then an intermediate examination, followed by the final examination. In his opinion, specialised training in foundry practice, such as that offered by the degree course, should be available to students. He would like to ask if it would be possible to make this degree course an external examination, as if so it would be a great asset to students all over the country.

The resolution was carried.

Prof. Andrew, in reply, expressed his pleasure that everyone present supported his scheme. Answering Mr. Tipper, he thought it would be impossible to have an external degree, because of the experimental work, which was a very necessary and important part of the course. The entrance qualification for the course had not yet been fixed, and he wanted the industry to have a large say in this matter, and in formulating the course, and he hoped to see leading members of the industry on the committee which organised the course.

Sensitivity of the Gamma-Ray Method of Radiography.—A Paper read recently before the American Society for Steel Treating, by Messrs. John T. Morton and Alfred Ziegler, at Detroit, described how blocks of iron of various thicknesses were radiographed using a capsule of radon as the source of gamma-rays. The thickness of each block was varied in regular steps and the optical densities of the resulting films were measured by means of a densitometer. From these measurements, the sensitivity of the method, which was defined as the change in thickness necessary to produce a 2 per cent. change in film density under certain specified conditions, was calculated. The results show that in the region from 2 to 6 in. of iron, the sensitivity is nearly constant at a value of about 1.3 per cent.

The Steel Castings Report.

In our next issue we hope to give a full and exclusive report of the discussion which took place under the chairmanship of Mr. J. H. S. Dickenson on November 7 before a joint meeting of the Sheffield Metallurgical Society and the local branch of the Institute of British Foundrymen. There were presented two written contributions, which we print below.

From MR. C. HOWELL KAIN (President of the London Branch of the Institute of British Foundrymen).

The Steel Castings Report starts with the assumption that all steel castings are unsound, and most of the work appears to have aimed at proving this. In a research report surely some indication should be given of potentialities and possibilities.

The statement on page 47 of the preprint that the expert founder regards an intricate and difficult design as a tribute to his skill can only be described as nonsense. The more expert the founder, the more likely he is to realise the inherent difficulties of producing intricate designs and to insist on modifications of design in accordance with the well-known laws of cooling and freezing. It is agreed that the expert founder would not suggest such modifications as casting solid and boring out, since this reduces him to the level of a maker of sash weights and firebars.

Commercial Aspect.

It appeared to him that too much attention had been paid to the commercial aspect of steel-casting production, since a Research Committee of this standing should be concerned solely with quality and not with mere competition. Their duty was to show that sound castings can be produced provided no regard is paid to cut-throat competition.

He found it almost impossible to discuss the various castings made, as it appeared that in no case had any of the possible variables been standardised, and so no two castings were directly comparable, but he should have wasted no time on examining the castings illustrated in Figs. 41, 42, 45, 46 or 51, and he could not understand why these castings were made unless an attempt was deliberately being made to make them unsound.

Foreign Work.

Since the publication of the Report, a memoir on Steel Castings, by C. W. Briggs and R. A. Gezelius, of the American Navy Department, has been published in THE FOUNDRY TRADE JOURNAL.* In this Paper definite indication is given of directions in which research might be done, and, also, a number of indications to the ordinary founder of methods for obtaining soundness. It appeared to him that these were the lines on which a research should be published in order to be of most use to the industry.

The unfortunate impression created by the Steel Castings Report was somewhat alleviated by the very complimentary report given of his British tour by Captain Louis Shane on his return to America after his recent tour of Europe.

He thought it must be obvious to everyone that in a report dealing exclusively with castings it would have been sound constructive policy to arrange the work in conjunction with the Institute of British Foundrymen, since this body possessed wider connections in the foundry industry than any other organisation.

Suggested Research Work.

He was afraid that the foregoing criticism was mostly destructive in nature. To turn to constructive suggestions, apart from physico-chemical and metallurgical considerations, the following two points appear to open up a fruitful field:—

(1) Uniformity of the section in the design was not necessarily conducive to soundness. This was pointed out by Mr. Jefferson at the Glasgow symposium, and, in a Paper the writer read to the Middlesbrough Branch last year, he showed that in a plain plate casting where the length and breadth respectively were 10 and 8 times the thickness, the centre of the plate was considerably weaker than the edges, irrespective of whether the plate was cast on end, on edge, flat or at an angle, and this in spite of the fact that the plates were apparently sound when sawn through. Did not this open up a fruitful field for investigation on the best design to ensure uniform physical properties throughout the section?

(2) It was possible by the use of very drastic external chilling to ensure soundness in a heavy section which it was difficult to feed in the normal manner. He had long felt that this section was not really ultimately sound, and this might be investigated either by exceedingly high-powered metallographical examination, or by X-ray.

From MR. N. F. BARNABY.

Whatever the cause was that led to the investigation on steel castings by the Engineering Research Board in 1925, and carried out since then by the Research Department, Woolwich, it had resulted in steel castings being scientifically examined and all their defects analysed in an unbiased manner. This is a welcome change from the attitude commonly adopted by non-foundrymen in the past. It has usually been the custom of purchasers to look on steel castings with suspicion, and attempts by the steel-founder to discuss the difficulties with buyers and some engineers have met with levity.

The Ingot Analogy.

It is very desirable that the comments by Mr. J. H. S. Dickenson during the discussion at the annual general meeting of the Iron and Steel Institute should be read by steel-castings purchasers, as well as by the founders. He said that "it was not to be expected that in this report the Committee would be in a position to lay down precise rules for the manufacture of steel castings, even of one or two selected special types, but in time this programme of work should lead to a much sounder conception than existed at the present time of the correct procedure to be followed in making this or that type of steel casting." He further alluded "to the great dilemma with which the steel-founder was faced in making a casting of complicated form. A steel ingot was the simplest form of casting, and any complicated casting could be considered as a collection of steel ingots all joined together. There were two main types of ingots—those cast from well-killed steel, which were solid in the body of the ingot but inevitably formed a shrinkage cavity within the discarded upper end, and those cast from semi-killed steel, which contained blowholes of sufficient capacity to compensate for the shrinkage, and this produced an ingot having no shrinkage cavity at the upper end. Each type had its sphere of usefulness, and according to the purpose intended the choice was made deliberately. But yet, whilst that was true as regarded single ingots, it seemed to be expected of a complicated steel casting that the final product should be completely sound, neither shrinkage cavities nor blowholes anywhere."

Mr. Dickenson specially pointed this out as one of the many matters which would have to be considered by the Committee, and he thought that many users who demanded perfectly sound steel castings in the most intricate forms quite overlooked this aspect of the problem.

Another contribution to the discussion should be read in conjunction with the Report, and that was the description by Sir Robert Hadfield of the complicated castings successfully made by his company when they were properly designed to suit the type of work and contraction of the steel.

More Moulding Data Wanted.

In regard to the Report itself, this deals very closely with the defects found in the castings examined, and also gives very full particulars of pouring methods, placing of heads, brackets, chills, etc., and of subsequent heat-treatment and testing; but the mould is only described in a general way. In the slewing cylinder shown in Fig. 7, a description of the core is given, but nothing is said about the mould. The strength of the moulding material, disposition of box bars and lifter irons, all influence the tendency for contraction to cause hot tears.

In all the examples showing cracks, hot tears, pulls or whatever they may be called, discovery of such by the founder would direct his attention to the method of moulding. In all first-class foundries steel is made that is beyond criticism so far as freedom from gases or high sulphur content is concerned; but the best steel cannot prevent the rupture during freezing of a casting which must contract and cannot.

It may be that the Committee have left the making of a suitable mould to the suppliers of the various castings; but a questionnaire was sent round to different foundry managers asking for suggestions for modification of design, the best way of making the pattern and the mould, and running and feeding the casting. This brought in reply diversity of ideas which were summarised in the report and mainly referred to design.

Experimentia Docet!

The castings sent in all contained defects of some sort, and a general reader would assume from the report that all steel castings of intricate design would suffer from similar defects; but it is most likely that all the suppliers of these castings could make the same type of castings sound ultimately after becoming aware of the defects in the earlier castings. It is this particular trouble that the steel founder has to face.

A new design has to be tried out before inherent defects can be eradicated, and in overcoming these defects, placing of feeding heads, runners, speed of casting, are no more important than the strength and finish of the mould.

Imperfections in Core Boxes.

The mould must be strong enough to stand assembling, but not much more; and it is in the assembling where so much depends. A pattern is often made with due consideration for the mould; but the coreboxes are not usually made with due consideration for the assembling and closing of the mould. Very often a "blind close" is unavoidable, due to want of consideration by the patternmaker, and no allowance for venting from one core to another is made by the coremaker, and again the mould has to be rubbed or hacked about to get the cores in and subsequently patched up. The foregoing are all a part of the making of a casting, and are influenced very largely by the pattern as it is sent to the founder by the customer.

This particular point is stressed in the summary by the Committee when they say that "if the very high standard demanded for highly-stressed castings is to be maintained it must be recognised that this standard is not easily attained; but that it involves a definite heavy outlay in special control of sands, make-up of moulds and cores and in providing adequate feeding of the casting."

Bouquets for the U.S.A.

As an object lesson in overcoming defects in intricate castings, one might consider the roller-stock castings very largely used in America, such

(*Concluded on page* 300.)

* FOUNDRY TRADE JOURNAL, September 21, 1933, page 157, *et seq.*

This Week's News in Brief.

Trade Talk.

Steam Plant Accessories, Limited, have removed from 38, Victoria Street, to 59, Palace Street, Victoria Street, Westminster, S.W.1.

Edinburgh Corporation Water Department have accepted the tender of Messrs. Cochrane & Company, Limited, Middlesbrough, for about 400 tons of cast-iron pipes of various sizes.

Messrs. Hall Russell & Company, Limited, Aberdeen, have received an order to build a new steam trawler of the most modern type, as regards form and equipment, and specially suited for South African service, for Sir John Irvine, on behalf of Messrs. Irvine & Johnston (South Africa), Limited.

Messrs. William Denny & Bros., Limited, Dumbarton, have booked orders for three shallow-draft vessels from the Irrawaddy Flotilla Company. The vessels will be all-welded as far as possible, and the propelling machinery, consisting of Diesel engines, will be provided by Messrs. J. G. Kincaid & Company, Limited, Greenock.

Messrs. Stewarts and Lloyds, Limited, have signed the contract for the removal of the steel mill from Clydesdale Works, Mossend, to Corby. The contract, worth £60,000, has been entrusted to Sir William Arrol & Company, Glasgow, and removal will begin early in January. The mill will close down on December 30, when over 600 men will be paid off.

The Zinc Cartel has circulated a letter asking its members to comment on the proposals of a quota reduction from 45 to 50 per cent., to so-called Ostend basis, and the raising of fines imposed for exceeding the quotas. It is understood that this circular has been issued because of the demand of a group of smaller members to observe strictly the 45 per cent. quota in view of the recent increase in stocks.

Messrs. Thomas Dudley, Limited, ironfounders, of Groveland Road, Dudley Port, have bought from the Dudley Corporation six acres of land on the Birmingham-Wolverhampton new road, as a site for a new works. The firm employs about 200 workers, and the company hopes soon to transfer all its activities to the new site and ultimately to double the number of employees. Building is to commence immediately.

Messrs. Hurst Nelson & Company, Limited, Motherwell, have secured a proportion of the order for new freight wagons on renewal account to provide for an extension of the L.M.S. railway company's policy of running an increased number of express freight trains. The new wagons are of 12 tons capacity, open type, for the conveyance of general merchandise, and will be fitted with continuous brakes. Messrs. Hurst Nelsons' share is 400 wagons.

The report of the directors of Messrs. Ibbotson Bros. & Company, Limited, Globe Steelworks, Sheffield, states that injury done to the works by war work on which the Government insisted, was so great that it was thought advisable to defer most of the repairs allowed for until the adjoining property could be acquired at reasonable prices and the whole works could be reorganised. The last of the property required has now been purchased and the reorganisation, which will cost more than £80,000, is proceeding.

Messrs. Glenfield & Kennedy, Limited, Kilmarnock, and Sir William Arrol & Company, Limited, Glasgow, have secured the contract, valued at £125,000, for the supply of sluice gates and the steelwork for the Gebel Awlia Dam, a few miles south of Khartoum, being built by a company formed for the purpose by Mr. J. W. Gibson, the well-known British engineer. Sir William Arrol & Company, Limited, are to supply lock gates, capstans, pontoons and a lift bridge, amounting in value to approximately £50,000.

Several important orders have been placed with Clyde firms. Messrs. Harland & Wolff, Limited, Govan, who have had an empty yard for several months, have received an order to build two 12,000-ton motorships, one a refrigerating cargo vessel, for Messrs. Shaw, Savill & Albion Company, Limited, and the other an oil tanker for the Anglo-Saxon Petroleum Company. The latter company have also ordered a similar vessel from Messrs. Lithgows, Limited, Port Glasgow, the engines for which will be manufactured by Messrs. John G. Kincaid & Company, Limited, Greenock. These contracts bring the total of vessels ordered from Clyde firms during November to 11, the value of the orders being greater than the total placed during the whole of last year.

Employment for a year in the building of ships' lifeboats is being provided by Messrs. Robsons (Boat Builders), Limited, South Shields. At present the firm has orders in hand for 46 boats, comprising 23 for Messrs. Swan, Hunter & Wigham Richardson, Limited, Walker-on-Tyne; four for the Furness Shipbuilding Company, Limited, Haverton Hill; nine for S. P. Austin & Son, Limited, Sunderland; four for Short Brothers, Limited, Sunderland; two for R. W. Hawthorn, Leslie & Company, Limited, Hebburn; two for the Blue Star Line; and two for service on the Nile River. The first of the Swan Hunter boats was launched last week. A busy period is being experienced by trawler builders in the South Yorkshire area, and in addition to the orders amounting to £400,000 already in hand, another contract for a trawler for Hudson Bros., Limited, of Hull, has been booked by Cochrane & Sons, Limited, of Selby.

The Steel Castings Report.

(*Concluded from page* 299.)

as side frames and bolsters of wagons. It is often assumed that the castings made in America are shoddy; but these particular castings are the result of very scientific and intensive testing. Before any design of casting is accepted by a railway, castings made to it are subjected to test in a very powerful testing machine, which reproduces all imaginable shocks and road strains until a flaw in the casting develops. This flaw is examined and alteration made to the design, and another made and tested. It is often necessary to make a series of alterations before satisfaction is obtained, and the present degree of excellence of this intricate type of casting has only been arrived at by making the castings in carefully-thought-out composite green-sand and dry-sand moulds—the green sand for the purpose of allowing the mould to give when shrinkage is taking place, and dry-sand cores and slabs for strength where needed and for covering machined faces. By this means a mould is possessed which allows for contraction movements, with the least stress in the freezing walls of the casting. This freedom to contract often results in distortion of shape in the casting when cold, and the trial castings show the amount which is allowed for by making the pattern different from the drawing sizes. He thought the Committee would do a great service to the founder if further investigations took into consideration what is involved in obtaining the most satisfactory mould.

New Companies.

Weldox, Limited, 35, New Cavendish Street, W.1.—Dealers in welding apparatus. Capital £1,000. Directors: A. W. Oyler and K. A. Steinkamp.

Taylor Machines, Limited, 695, Salisbury House, London Wall, E.C.—Ironfounders, mechanical engineers, etc. Capital £250. Directors: J. M. W. North and C. H. Taylor.

Aldridge Tool & Engineering Company, Limited, Whetstone Works, Whetstone Lane, Aldridge, Staffs.—Manufacturers of engineers' small tools, etc. Capital £4,000. Directors: C. B. Clay, H. B. Clay and J. Clay.

Contracts Open.

Cardiff, November 27.—Cast-iron pipes and special castings, 9 in. dia. and under, for the Town Council. Mr. N. J. Peters, water engineer and manager, City Hall, Cardiff.

Swansea, December 4.—Steam and feed water piping, valves, etc., for the new power station at Tir John. Messrs. Preece, Cardew & Rider, 8-10, Queen Anne's Gate, Westminster, S.W.1. (Fee £5 5s., returnable.)

Personal.

Mr. John Weir, a director of Messrs. R. & H. Green & Silley Weir, Limited, engineers and ship repairers, has resigned his seat on the board owing to ill-health.

Mr. Joseph Bamford, head of Messrs. Bamfords, Limited, of Uttoxeter, and Mrs. Bamford celebrated their golden wedding anniversary on Friday, November 10, and were the recipients of presentations from the workmen and staff.

Mr. Percy Lister, managing director of Messrs. R. A. Lister & Company, Limited, of Dursley (Glos), is starting next week on a world tour to investigate trading conditions in the United States, Canada, Australia, New Zealand and Asia.

Mr. A. D. Kirby has resigned his position as foundry manager with the National Steel Foundry (1914), Limited, in order to take up a similar position with Messrs. Coltness Iron Company, Limited, Newmains, Lanarkshire.

The Council of the Institution of Civil Engineers have awarded the Coopers Hill War Memorial Prize for 1932 to Mr. E. F. Reid, M.A., Assoc.M.Inst.C.E. (Oxford), for his Paper on "Failures in Steel and Cast-Iron Mains and Provision for their Protection." This prize was founded by the Coopers Hill Society in memory of Coopers Hill men who lost their lives in the war.

Mr. and Mrs. James M'Crum, 9, Robertson Place, Kilmarnock, have celebrated their golden wedding. Mr. M'Crum was employed by Messrs. Glenfield & Kennedy, Limited, in the light-iron foundry for half a century. He retired in April, 1928. At that time he was presented with a gold watch from his colleagues, and in 1930 he received a gold service medal from the firm. Over 120 friends and relatives attended the anniversary celebrations in Kilmarnock last week, when Mr. and Mrs McClum received many presents.

Wills.

Kenrick, J. A., of Edgbaston and West Bromwich, ironfounder	£83,793
Gibson, Sydney William, of Eynsford, Kent, engineer and ironfounder ...	£17,620
Glegg, Sir Alexander, a director of Messrs. John I. Thornycroft & Company, Limited, and other companies	£51,210
Wailes-Fairbairn, W. F., late a director of Messrs. Fairbairn, Lawson, Combe, Barbour, Limited, of the Wellington Foundry, Leeds	£108,897

Obituary.

Mr. B. H. W. Hewett, engineer in charge of the new Mersey Tunnel, died suddenly on Tuesday, November 14, at West Kirby, Cheshire, aged 58.

Mr. John Graham, for several years secretary and later general manager of the Millom & Askam Hematite Iron Company, Limited, has died at Millom, aged 71.

The death occurred very suddenly at his home in Hurlford, near Kilmarnock, on November 11, of Mr. James Thom Rankin, J.P., of Messrs. William Baird & Company, Limited.

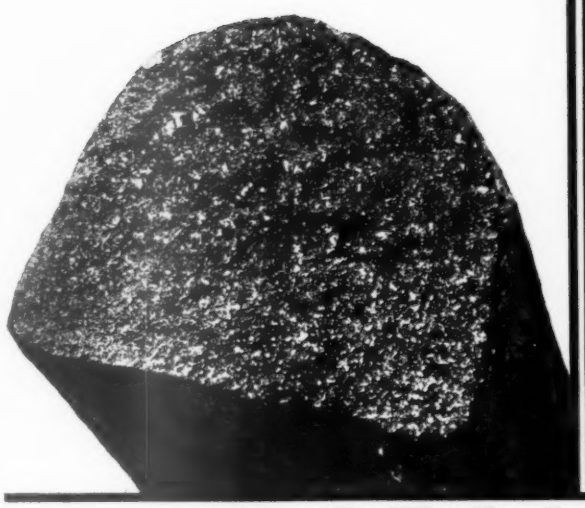
The death occurred on Sunday, November 19, at the age of 75, of Mr. John Smith, a founder and the managing director of the Rustless Iron Company, Limited, Trico Works, Keighley.

Mr. Robert Main died at his residence in Bothwell on November 14. He was well known in iron and steel circles in Scotland, and was for many years one of the principal partners in Messrs. Merry & Cunningham, Limited, coal and ironmasters.

The death occurred at his home in Glasgow of Mr. Peter Mitchell, on November 11. Mr. Mitchell, who had reached his 71st year, left his native town of Falkirk about 18 months ago to reside in Glasgow. He was for many years works foreman at the Etna Foundry of Messrs. Watson Gow & Company, Limited, Falkirk.

The death occurred suddenly on November 14 of Mr. John Arthur Rudd, a well-known Glasgow engineer. Mr. Rudd was at business and died in the office. He was well known in marine, electrical and colliery-engineering circles, and an active member of many technical societies. Mr. Rudd was a native of Cumberland and had been connected with engineering in the Clyde district for over 50 years. He served his apprenticeship with Messrs. R. Napier & Son, Glasgow, and finally, through his own firm of J. A. Rudd & Company, carried out many important contracts.

XUM



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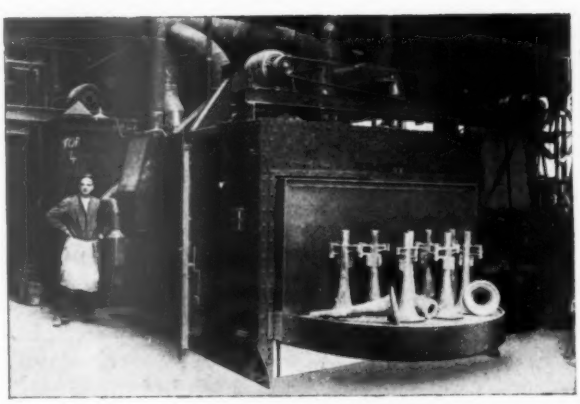

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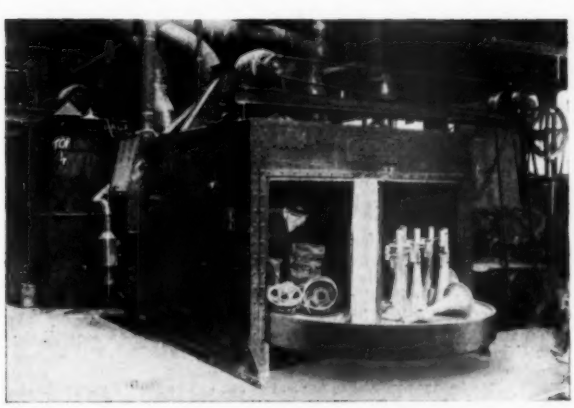

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19631

Raw Material Markets.

THE pig-iron markets continue to make steady progress. The current volume of business is not very large, as many consumers are already covered ahead, but there are still users who would be willing to enter into further commitments, in view of the possibility of increased prices in 1934. Heavy specifications for deliveries continue to be made against running contracts, and in some cases steps have had to be taken to increase output.

Pig-Iron.

MIDDLESBROUGH.—A firm market situation exists in the Cleveland iron trade. The ironmasters have sold practically their entire output to the end of the year, and any small parcels still outstanding are promptly taken up by consumers. The latter are ready to book forward at current rates, and several contracts have been made extending to the end of March, and in some cases even further. The available output of foundry barely equals the current demand, and, in view of the depletion of makers' stocks, the restarting of one or more stacks at an early date is not unlikely. Middlesbrough iron is in increasing demand from Scotland. Falkirk foundrymen can still buy at a preferential rate, the price of No. 3 Cleveland G.M.B. delivered Falkirk being 62s. 3d. per ton, compared with 62s. 6d. delivered Middlesbrough, 64s. 6d. delivered North-East Coast and 65s. 3d. delivered Glasgow. No. 1 foundry iron is 2s. 6d. per ton more than No. 3 G.M.B. and No. 4 foundry and No. 4 forge grades are 1s. per ton less.

The demand for East Coast hematite is so heavy that, despite the increased output, further withdrawals have had to be made from stock. The producers have very little iron for disposal over the next two or three months, and are adopting a reserved attitude in regard to forward business. There is a possibility of a further increase in quotations. For the present, however, the prices remain at 62s. 6d. per ton for East Coast mixed numbers and 63s. per ton for No. 1 quality.

LANCASHIRE.—There has been a further slight expansion in the call for pig-iron in this area, and the pig-iron makers believe that, after a long period, the supplies of machinery scrap, available after the breaking-up of mill machinery, are beginning to contract. These supplies have had a serious effect locally upon the consumption of new iron. Somewhat better reports are forthcoming as to activity amongst consumers. Prices are unchanged. For delivery to users in the Manchester zone, Derbyshire and Staffordshire No. 3 foundry iron are on offer on the basis of 67s. per ton, with Northamptonshire at 65s. 6d.. Derbyshire forge at 62s.. Scottish foundry at about 80s., East Coast hematite at 76s. 6d., and West Coast at from 80s. 6d. to 81s. per ton.

MIDLANDS.—Prospects in this area are now very bright compared with twelve months ago. Some furnaces are already fully booked and are having to put a brake upon forward contracts. The founders are booking as much as they can, fearing that increased coke prices may lead to higher pig-iron values. There is no immediate danger of a shortage of supplies of iron, however, as good stocks are held at most furnaces. Current prices are unchanged at 62s. 6d. for No. 3 Northants and 66s. for Derbyshire, Staffordshire and Lincolnshire No. 3, delivered Birmingham and Black Country stations and less rebate to large consumers. No Continental foundry iron is coming through to this locality, and only small supplies of Cleveland iron are arriving, as the price of 72s. 6d. is not competitive. With the improvement in the engineering trade, there is a better demand for special pig-iron. Scottish No. 3 is about 85s. per ton delivered, medium-phosphorus pig from 70s. to 80s., and low-phosphorus iron 80s. to 90s. delivered here. For special high-duty work, refined pig-iron is offered at rates between £5 15s. and £6 15s.

SCOTLAND.—The demand for Scottish iron remains slow and spasmodic, consumers of this grade being poorly employed and only able to buy from day to day as needs arise. Good quantities of Cleveland iron continue to be taken by the light-castings makers, who are still busily employed. The price of Scottish iron is unchanged at 65s. f.o.t. furnaces for No. 3 foundry, with 2s. 6d. per ton extra for No. 1. No. 3 Middlesbrough is still quoted at 62s. 3d. f.o.t. Falkirk and 65s. 3d. f.o.t. Glasgow. Iron from the Midlands is obtainable at 1s. 3d. per ton below these figures.

Coke.

There has been a wide demand for foundry coke, owing to the expectation of an upward move in prices. Quotations are, however, still unchanged, as follow:—Best Durham coke, 36s. to 38s.; Scottish low-ash coke, 38s. 6d. to 39s.; Welsh coke, according to quality, 31s. 6d. to 45s., delivered in the South Staffordshire area.

Steel.

Active conditions continue to rule in the steel markets, and in several branches of the industry there is considerable pressure on the part of consumers to secure deliveries, states the official report of the London Iron and Steel Exchange. Export business is still on a smaller scale than might be expected in view of the large volume of inquiry. Difficulties in the way of conducting overseas trade, however, show no signs of relaxing. Busy conditions rule in the semi-finished steel department, and the British makers' delivery dates are being gradually extended, while prices show a tendency to advance. Continental material is being offered in this market, and sales have increased slightly of late, although prices have been advanced. In the finished-steel section of the market a strong home demand is the principal feature of the position. Recent railway orders and the prospects of more business being transacted in shipbuilding steel have helped to improve confidence, and there is a greater inclination noticeable among consumers to enter into forward contracts.

Scrap.

The scrap-iron markets generally maintain their firm position. In the Cleveland area many foundries are buying as much material as they can, believing that a rise in prices is imminent. There is a distinct tightening of supplies in this district. Quotations are very firm in the Midlands, and merchants will not book forward even at to-day's already increased levels. A fair demand exists for light scrap iron in South Wales, but the call for other grades is weak in this district. Similar conditions have ruled in Scotland, but the inquiry from foundries has improved somewhat during the last few days.

Metals.

Copper.—The price of standard copper made a slight recovery towards the end of last week, but subsequently relapsed, Monday's level being £29 5s. per ton. There has been a certain amount of purchasing at the lower levels by consumers, both here and on the Continent. The future of the market remains very uncertain, and a reliable statement with regard to the Federal Government's dollar policy would be of great value in steadying the market. Good supplies of copper continue to arrive in this country, particularly from Canada, where the metal is largely a "by-product" so far as a number of the big mining groups are concerned, and has to be disposed of regularly in order not to impede the working of nickel, gold, etc.

The week's prices have been as follow:—

Cash.—Thursday, £28 15s. to £28 16s. 3d.; Friday, £29 12s. 6d to £29 15s.; Monday, £29 5s. to £29 6s. 3d.; Tuesday, £29 6s. 3d. to £29 7s. 6d.; Wednesday, £29 7s. 6d. to £29 8s. 9d.

Three Months.—Thursday, £28 17s. 6d. to £28 18s. 9d.; Friday, £29 16s. 3d. to £29 17s. 6d.; Monday, £29 7s. 6d. to £29 8s. 9d.; Tuesday, £29 10s. to £29 11s. 3d.; Wednesday, £29 10s. to £29 11s. 3d.

Tin.—The easier tendency which this market has lately displayed must be ascribed to the unsettling influences of the American situation, and the weakness of copper and other markets, the uncertain outlook occasioning some selling and liquidation. The inherent strength of the market, however, due to the substantial improvement which has just taken place in the statistical position and which seems likely to continue, reasserted itself, and the price has since recovered from the lowest. The fact that the market suffered so little depreciation, having in view the depressing circumstances, would seem to be a good indication of the fundamental strength of the position. Trade demand in this country is fairly well maintained, and a moderate business is reported from the Continent, but in America less activity has obtained, due no doubt to the conditions prevailing there, states the weekly report of Messrs. Rudolf Wolff & Company.

Daily quotations:—

Cash.—Thursday, £226 15s. to £227; Friday, £226 12s. 6d. to £227; Monday, £227 15s. to £228; Tuesday, £227 15s. to £227 17s. 6d.; Wednesday, £227 7s. 6d. to £227 10s.

Three Months.—Thursday, £226 7s. 6d. to £226 10s.; Friday, £226 5s. to £226 10s.; Monday, £227 12s. 6d. to £227 15s.; Tuesday, £227 12s. 6d. to £227 15s.; Wednesday, £227 7s. 6d. to £227 10s.

Spelter.—Following the recent decline in prices, a fair amount of buying by consumers was seen, general buying by the galvanising trade being reported. There has also been a better call for high-grade metal. No announcement has yet been made as to the future policy of the Zinc Cartel.

Price fluctuations:—

Ordinary.—Thursday, £14 12s. 6d.; Friday, £15; Monday, £14 16s. 3d.; Tuesday, £14 10s.; Wednesday, £14 8s. 9d.

Lead.—Late last week consumers became interested by the attractive price level prevailing, and good purchases were made. The price did not recover much, but, nevertheless, the undertone was greatly improved. Producing costs in some countries have been lowered as a result of the fluctuations of exchange, and consumption is increasing, report Messrs. Brandeis, Goldschmidt.

Daily market prices:—

Soft Foreign (Prompt).—Thursday, £11 2s. 6d.; Friday, £11 8s. 9d.; Monday, £11 5s.; Tuesday, £11 3s. 9d.; Wednesday, £11 3s. 9d.

London Foundrymen's Dinner.

The Annual Dinner of the London Branch of the Institute of British Foundrymen, which is to be held at 7.15 for 7.45 at the Charing Cross Hotel on December 13 is generally favoured by a number of guests from the provinces. This year a special effort has been made to enliven what has always been a lively evening.

The guests include Viscount Lymington, Mr. C. E. Williams, President of the Institute, and Major Freeth, F.R.S., President of the British Cast Iron Research Association, while Ronald Frankau, of wireless fame, and John Lovering have been engaged to entertain the guests. The Council will be pleased for provincial members of the Institute to participate. The cost of tickets is 10s. 6d. (excluding wines), and these are obtainable from the honorary secretary, Mr. H. W. Lockwood, Winchester House, Old Broad Street, London, E.C.2. Owing to limited accommodation it has been deemed impossible to include lady guests. This, of course, does not apply to women members of the Institute.

Notes from I.B.F. Branches.

Members of the Wales and Monmouth Branch of the Institute of British Foundrymen are officially invited to visit the Engineers' Exhibition at Cardiff on December 2, the date on which a Paper will be given at the South Wales College, Newport Road, Cardiff, on "Test-Bars from the Foundrymen's Point of View," by Mr. S. Southcott.

The visit is timed for 3 p.m., and the party will be officially received by the promoters of the exhibition. Any other members of the I.B.F. who happen to be in that area at the time will be welcome to join the party.

Desulphurisation of Cast Iron.—The efficient desulphurisation of cast iron with sodium carbonate requires, according to L. F. GIRARDET and R. LELIÈVRE in "Rev. Metallurg.," the removal of the slag from the metal prior to treatment, because the combined action of the carbonate and the carbon in the metal liberates sodium which attacks the slag before the sulphur in the metal. It is also important to remove the Na_2S slag before casting; treatment tends to reduce the Si content of the metal.

XUM

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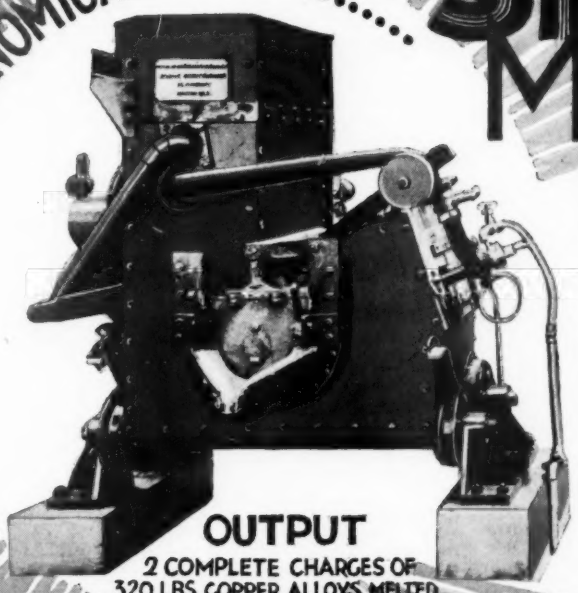
The way to BETTER castings

WARNER & CO. LTD. CARGO FLEET MIDDLESBROUGH

FOR FAST & ECONOMICAL MELTING.....

SKLENAR Midget FURNACE



OUTPUT
2 COMPLETE CHARGES OF 320 LBS. COPPER ALLOYS MELTED IN ONE HOUR AFTER PREHEAT

OIL-FIRED

CHARACTERISTIC FEATURES:

No crucibles or pit fires required; Compact with rapidity of service; Perfect control of atmospheric conditions in the furnace with temperatures ranging from 900°C. to 1600°C.; Low fuel consumption; Better metal and reduced metallic losses; Metal under observation throughout; Reduced cost of upkeep; Cost of production reduced 60%; Perfect control of alloys; Oil burning equipment capable of running for long periods without fear of breakdown.

OIL CONSUMPTION: 4½ gallons per hour of fuel oil.
OTHER STANDARD SIZES FOR NON-FERROUS METALS: Coke or Oil fired up to 2 tons. Larger sizes on application.
OIL FIRED FURNACES FOR MELTING GREY IRON AND SEMI-STEEL: Sizes and prices on application.

WILL SAVE UP TO £900 PER ANNUM.

SEND US YOUR ENQUIRIES — OUR TECHNICAL STAFF IS AT YOUR SERVICE.

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BRITISH REVERBERATORY FURNACES LTD.
88. KINGSWAY · LONDON. W.C.2.

RAW MATERIALS—PRICE LIST.

(Wednesday, November 22, 1933.)

COPPER.

	£	s.	d.
Standard cash	29	7	6
Three months	29	10	0
Electrolytic	32	10	0
Tough	31	10	0
Best selected	32	0	0
Sheets	60	0	0
India	41	10	0
Wire bars	33	10	0
Ingot bars	33	10	0
H.C. wire rods	35	15	0
Off. av. cash, October	33	13	10 3/4
Do., 3 mths., October	33	17	2 1/4
Do., Sttlmnt., October	33	14	1 1/4
Do., Electro, October	37	7	0 9/11
Do., B.S., October	36	6	4 8/11
Do., wire bars, October	37	14	6 9/11
Solid drawn tubes			9 3/4d.
Brazed tubes			9 3/4d.
Wire			6 1/2d.

BRASS.

Solid drawn tubes	8 3/4d.
Brazed tubes	10 3/4d.
Rods, drawn	8 1/2d.
Rods, extd. or rlld.	4 3/4d.
Sheets to 10 w.g.	7 3/4d.
Wire	7 3/4d.
Rolled metal	6 7/8d.
Yellow metal rods	4 3/4d.
Do. 4 × 4 Squares	5 3/4d.
Do. 4 × 3 Sheets	5 3/4d.

TIN.

	£	s.	d.
Standard cash	227	7	6
Three months	227	7	6
English	228	0	0
Bars	229	15	0
Straits	231	15	0
Australian (nom.)	—		
Eastern	232	15	0
Banca	230	15	0
Off. av. cash, October	223	10	7 1/2
Do., 3 mths., October	223	8	11 1/2
Do., Sttlmt., October	223	10	10 1/2

SPELTER.

	£	s.	d.
Ordinary	14	8	9
Remelted	14	15	0
Hard	12	10	0
Electro 99.9	17	0	0
English	15	5	0
India	14	15	0
Zinc dust	20	0	0
Zinc ashes	3	5	0
Off. aver., October	16	9	1 1/2
Aver. spot, October	16	6	2 3/8

LEAD.

	£	s.	d.
Soft foreign ppt.	11	3	9
Empire	11	8	9
English	12	15	0
Off. average, October	11	19	0 3/4
Average spot, October	11	16	0 2 1/2

ALUMINIUM.

Ingots	£100 to £105
Wire	1/1 to 1/9 lb.
Sheet and foil	1/2 to 2/9 lb.

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	25	10	0
Do., V.M. ex whse.	23	10	0
Rods	28	5	0

ANTIMONY.

	£	s.	d.		£	s.	d.
English	37	10	0	to 40	0	0	
Chinese, ex-whse.				26	15	0	
Crude				20	10	0	

QUICKSILVER.

	£	s.	d.		£	s.	d.
Quicksilver	9	10	0	to 10	0	0	

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	£6 10 0
45/50%	£12 10 0
75%	£18 2 6
Ferro-vanadium—	
35 50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free of Mo.	5/6 per lb.
Ferro-titanium—	
23/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£14 10 0
Ferro-tungsten—	
80/85%	2/6 lb.
Tungsten metal powder—	
98/99%	2/9 lb.
Ferro-chrome—	
2/4% car.	£32 0 0
4/6% car.	£23 10 0
6/8% car.	£21 12 6
8/10% car.	£20 12 6
Ferro-chrome—	
Max. 2% car.	£34 10 0
Max. 1% car.	£35 12 6
Max. 0.70% car.	£37 10 0
70%, carbon-free	10 1/2d. lb.
Nickel—99.5/100%	£225 to £230
"F" nickel shot	£202 10 0
Ferro-cobalt, 98/99%	5/6 lb.
Metallic chromium—	
96/98%	2/8 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to £11 5 0
76/80% packed	£11 15 0 to £12 5 0
76/80% export	(nom.) £9 15 0
Metallic manganese—	
94/96% carbon-free	1/2 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under 1/8 in. to 1/4 in.	3d. lb.
Do., under 1/4 in. to 1/16 in.	1/- lb.
Flats, 1/8 in. × 1/4 in. to under 1 in. × 3/8 in.	3d. lb.
Do., under 1/8 in. × 1/4 in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP.

	£	s.	d.		£	s.	d.
South Wales—							
Heavy steel				2	10	0	
Bundled steel and shrngs.	2	5	0	to 2	10	0	
Mixed iron and steel	2	5	0	to 2	6	6	
Heavy cast iron	2	5	0	to 2	6	0	
Good machinery				2	7	6	
Cleveland—							
Heavy steel				2	7	6	
Steel turnings				1	11	6	
Cast-iron borings				1	2	0	
Heavy forge				2	10	0	
W.I. piling scrap				2	5	0	
Cast-iron scrap	2	7	6	to 2	9	0	
Midlands—							
Light cast-iron scrap	2	0	0	to 2	2	6	
Heavy wrought iron	2	10	0	to 2	15	0	
Steel turnings, f.o.r.				1	8	0	
Scotland—							
Heavy steel	2	6	3	to 2	7	6	
Ordinary cast iron	2	7	6	to 2	8	0	
Engineers' turnings				1	15	0	
Cast-iron borings				1	15	0	
Wrought-iron piling				2	10	0	
Heavy machinery	2	10	0	to 2	11	6	

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	24	0	0
Brass	17	10	0
Lead (less usual draft)	10	5	0
Tea lead	7	10	0
Zinc	10	0	0
New aluminium cuttings	73	0	0
Braziery copper	22	0	0
Gunmetal	23	0	0
Hollow pewter	145	0	0
Shaped black pewter	105	0	0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	65/-
Foundry No. 3	62/6
,, at Falkirk	62/3
,, at Glasgow	65/3
Foundry No. 4	61/6
Forge No. 4	61/6
Hematite No. 1, f.o.t.	63/-
Hematite M/Nos., f.o.t.	62/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	68/6
,, d/d Birm.	84/6
Malleable iron d/d Birm.	115/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	62/-
,, No. 3 fdry.	66/-
Northants forge	58/6
,, fdry. No. 3	62/6
,, fdry. No. 1	65/6
Derbyshire forge	62/-
,, fdry. No. 3	66/-
,, fdry. No. 1	69/-
Scotland—	
Foundry No. 1	67/6
,, No. 3	65/-
Hem. M/Nos. d/d	66/-
Sheffield (d/d district)—	
Derby forge	59/6
,, fdry. No. 3	63/6
Lincs forge	59/6
,, fdry. No. 3	63/6
E.C. hematite	76/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	67/-
Staffs fdry. No. 3	67/-
Northants fdry. No. 3	65/6
Cleveland fdry. No. 3	67/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	80/-
Clyde, No. 3	80/-
Monkland, No. 3	80/-
Summerlee, No. 3	80/-
Eglinton, No. 3	80/-
Gartsherrie, No. 3	80/-
Shotts, No. 3	80/-

FINISHED IRON AND STEEL.

Usual district deliveries for iron; delivered consumer's station for steel.

	£	s.	d.		£	s.	d.
Iron—							
Bars (cr.)	9	0	0	to 9	15	0	
Nut and bolt iron	6	17	6	to 7	10	0	
Hoops	10	10	0	to 12	0	0	
Marked bars (Staffs) f.o.t.				12	0	0	
Gas strip	10	10	0	to 12	0	0	
Bolts and nuts, 3/4 in. × 4 in.	13	10	0				
Steel—							
Plates, ship, etc.	8	15	0	to 8	17	6	
Boiler plts.				8	5	0	
Chequer plts.				10	7	6	
Angles				8	7	6	
Tees				9	7	6	
Joists				8	15	0	
Rounds and squares, 3 in. to 5 1/2 in.				9	7	6	
Rounds under 3 in. to 3/8 in. (Untested)	7	10	0	& up.			
Flats—8 in. wide and over	8	12	6				
,, under 8 in. and over 5 in.	8	17	6				
Rails, heavy	8	5	0	to 8	10	0	
Fishplates				12	0	0	
Hoops (Staffs)	10	10	0	& up.			
Black sheets, 24g. (4-t. lots)	10	5	0				
Galv. cor. shts. (,,)	12	15	0				
Galv. flat shts. (,,)	13	5	0				
Galv. fencing wire, 8g. plain	14	0	0				
Billets, soft	5	10	0	to 5	15	0	
Billets, hard	6	17	6	to 7	2	6	
Sheet bars	5	0	0	to 5	7	6	
Tin bars				5	0	0	

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	10 3/4d.
Sheet to 10 w.g.	11 1/2d.
Wire	11 1/2d.
Rods	10 3/4d.
Tubes	14 1/2d.
Castings	12 1/2d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1 1/2 to 1/7 1/2
To 15 in. wide	1/1 1/2 to 1/7 1/2
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2 1/2 to 1/8 1/2
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3 1/2
Ingots rolled to spoon size	10d. to 1/6 1/2
Wire round—	
to 10g.	1/4 1/2 to 1/11 1/2

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3 1/2 upwards.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	18.26
No. 2 foundry, Valley	17.50
No. 2 foundry, Birm.	13.50
Basic	18.89
Bessemer	19.76
Malleable	19.39
Grey forge	19.39
Ferro-mang. 80%, seaboard	82.00
O.-h. rails, h'y, at mill	36.37 1/2
Billets	26.00
Sheet bars	26.00
Wire rods	35.00
	Cents.
Iron bars, Phila.	1.74
Steel bars	1.75
Tank plates	1.70
Beams, etc.	1.70
Skelp, grooved steel	1.60
Steel hoops	1.85
Sheets, black, No. 24	2.25
Sheets, galv., No. 24	2.85
Wire nails	2.10
Plain wire	2.10
Barbed wire, galv.	2.60
Tinplates, 100-lb. box	$4.65

COKE (at ovens).

Welsh foundry	20/- to 25/-
,, furnace	15/- to 17/-
Durham foundry	21/- to 25/-
,, furnace	15/-
Midlands, foundry	—
,, furnace	—

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	16/9 to 17/1 1/2
,,	28×20 ,,	33/6 to 34/3
,,	20×10 ,,	24/1 1/2 to 24/6
,,	18 3/4×14 ,,	17/7 1/2 to 17/9
C.W.	20×14 ,,	15/3 to 15/6
,,	28×20 ,,	32/3 to 32/6
,,	20×10 ,,	22/6 to 23/-
,,	18 3/4×14 ,,	15/7 1/2 to 15/9

SWEDISH CHARCOAL IRON & STEEL.

	£	s.	d.		£	s.	d.
Pig-iron	£6	0	0	to £7	0	0	
Bars-hammered, basis	£16	0	0	to £16	10	0	
Bars and nail-rods, rolled, basis	£15	15	0	to £16	0	0	
Blooms	£10	0	0	to £12	0	0	
Keg steel	£30	0	0	to £31	0	0	
Faggot steel	£18	0	0	to £23	0	0	
Bars and rods dead soft, st'l	£10	0	0	to £12	0	0	

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.	
Nov. 16	..	28	15	0	dec. 12/6
„ 17	..	29	12	6	inc. 17/6
„ 20	..	29	5	0	dec. 7/6
„ 21	..	29	6	3	inc. 1/3
„ 22	..	29	7	6	„ 1/3

Electrolytic Copper.

		£	s.	d.	
Nov. 16	..	32	0	0	dec. 20/-
„ 17	..	33	0	0	inc. 20/-
„ 20	..	32	10	0	dec. 10/-
„ 21	..	32	10	0	No change
„ 22	..	32	10	0	„ „

Standard Tin (cash).

		£	s.	d.	
Nov. 16	..	226	15	0	No change
„ 17	..	226	12	6	dec. 2/6
„ 20	..	227	15	0	inc. 22/6
„ 21	..	227	15	0	No change
„ 22	..	227	7	6	dec. 7/6

Tin (English ingots).

		£	s.	d.	
Nov. 16	..	227	10	0	inc. 5/-
„ 17	..	227	5	0	dec. 5/-
„ 20	..	228	10	0	inc. 25/-
„ 21	..	228	5	0	dec. 5/-
„ 22	..	228	0	0	„ 5/-

Spelter (ordinary).

		£	s.	d.	
Nov. 16	..	14	12	6	inc. 2/6
„ 17	..	15	0	0	„ 7/6
„ 20	..	14	16	3	dec. 3/9
„ 21	..	14	10	0	„ 6/3
„ 22	..	14	8	9	„ 1/3

Spelter (Electro, 99.9 per cent.).

		£	s.	d.	
Nov. 16	..	17	2	6	inc. 2/6
„ 17	..	17	5	0	„ 2/6
„ 20	..	17	0	0	dec. 5/-
„ 21	..	17	0	0	No change
„ 22	..	17	0	0	„ „

Zinc Sheets (English).

		£	s.	d.	
Nov. 16	..	25	10	0	No change
„ 17	..	25	10	0	„ „
„ 20	..	25	10	0	„ „
„ 21	..	25	10	0	„ „
„ 22	..	25	10	0	„ „

Lead (English).

		£	s.	d.	
Nov. 16	..	12	10	0	No change
„ 17	..	12	15	0	inc. 5/-
„ 20	..	12	15	0	No change
„ 21	..	12	15	0	„ „
„ 22	..	12	15	0	„ „

AVERAGE MONTHLY PRICES OF FURNACE COKE D/D MIDDLESBROUGH.

Year	January	February	March	April	May	June	July	August	September	October	November	December	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1901	0 17 6	0 14 0	0 13 0	0 14 0	0 14 6	0 15 0	0 15 3	0 15 3	0 15 9	0 16 6	0 16 9	0 16 9	0 16 4½
1902	0 16 9	0 15 0	0 15 6	0 15 0	0 15 0	0 15 3	0 15 3	0 15 3	0 15 6	0 16 0	0 16 6	0 16 0	0 15 5
1903	0 15 9	0 16 0	0 16 3	0 16 9	0 16 6	0 16 3	0 16 0	0 15 9	0 15 6	0 15 0	0 14 6	0 14 0	0 15 8½
1904	0 13 9	0 13 9	0 13 3	0 14 3	0 14 6	0 14 3	0 14 3	0 14 3	0 14 3	0 14 0	0 14 0	0 14 6	0 14 1½
1905	0 14 9	0 15 3	0 15 3	0 15 3	0 15 6	0 15 6	0 15 6	0 15 6	0 15 6	0 15 6	0 15 9	0 17 0	0 15 5½
1906	0 17 6	0 17 6	0 17 0	0 17 0	0 17 0	0 16 6	0 17 0	0 17 0	0 18 3	0 18 6	0 19 0	1 0 0	0 17 8½
1907	1 4 6	1 5 0	1 5 0	1 0 6	1 2 0	1 1 0	1 1 0	1 1 0	1 2 0	1 1 6	1 0 0	0 17 0	1 1 8½
1908	0 16 0	0 16 0	0 15 6	0 16 0	0 16 3	0 16 0	0 15 6	0 15 6	0 15 6	0 15 3	0 16 0	0 16 0	0 15 9½
1909	0 16 0	0 15 3	0 15 0	0 14 9	0 15 6	0 15 9	0 15 6	0 15 6	0 16 6	0 17 0	0 17 6	0 17 0	0 15 11½
1910	0 18 4½	0 18 6½	0 18 0	0 18 0	0 17 10½	0 17 0	0 16 1½	0 15 9½	0 15 11	0 16 0	0 15 9½	0 15 8	0 16 11
1911	0 16 0	0 15 10½	0 15 6	0 15 3	0 14 9	0 14 6	0 14 6	0 14 6	0 14 6	0 14 11½	0 15 0½	0 16 3½	0 15 1½
1912	0 17 3	0 17 3	0 18 6	0 18 10	0 19 0	0 19 4½	0 19 10½	1 0 9½	1 2 9	1 4 1½	1 5 8½	1 8 6	1 1 0
1913	1 5 9	1 4 11	1 5 0	1 5 0	1 4 9½	1 0 4½	0 19 5½	0 18 3	0 18 0	0 18 2½	0 18 6	0 18 6	1 1 4½
1914	0 18 2	0 17 1	0 17 0	0 17 0	0 17 4	0 17 6	0 17 6	0 18 5	0 18 4	0 17 9	0 17 6	0 18 5	0 17 8
1915	0 17 10½	0 17 9	1 0 4½	1 7 7½	1 9 4½	1 10 7½	1 9 7	1 7 3	1 5 4	1 4 9	1 9 6	1 13 0	1 6 1
1916	1 10 9	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6½
1917	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 14 3	1 15 6	1 11 2½
1918	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6
1919	1 15 6	1 15 6	1 15 6	1 15 6	2 1 6	2 1 6	2 3 9	2 10 6	2 10 6	2 10 6	2 10 6	2 10 6	2 3 8
1920	2 12 3	2 14 0	2 19 0	2 19 0	3 3 8	3 6 0	3 6 0	3 6 0	3 6 0	3 6 0	3 6 0	3 6 0	3 2 6
1921	3 1 0½	2 19 0	2 16 0	2 7 0	2 6 6	2 6 6	2 0 6	2 0 0	1 13 11	1 12 9	1 10 4½	1 8 3	2 3 6½
1922	1 7 0½	1 8 1½	1 9 7½	1 8 4½	1 7 11½	1 7 3	1 6 9½	1 6 10½	1 7 0½	1 10 2½	1 10 0	1 9 11½	1 8 3½
1923	1 11 3	1 14 6	2 0 1½	2 2 8½	2 4 4½	2 2 10½	2 1 0½	2 1 6	2 0 9½	1 18 9	1 18 8½	1 18 3	1 19 7½
1924	1 16 6½	1 14 9	1 11 11½	1 10 0½	1 8 1½	1 7 8½	1 7 3	1 6 3	1 6 0	1 5 0	1 5 0	1 5 0	1 9 5½
1925	1 4 10½	1 4 1½	1 13 3	1 2 4½	1 2 2½	1 1 5½	1 1 3½	1 4 9	0 18 10½	0 18 4½	0 19 6½	1 1 4½	1 2 8½
1926	1 2 1½	1 0 9	0 19 2½	0 18 6½	*	*	*	*	*	*	*	1 5 0	1 1 1½ ‖
1927	1 5 6	1 4 9½	1 6 1½	1 3 9	1 2 6	1 0 8½	0 19 4½	0 19 0	0 18 7½	0 18 0	0 17 10½	0 17 6	1 1 1½
1928	0 17 6	0 17 10½	0 18 0½	0 17 11½	0 17 8½	0 17 6½	0 17 7½	0 17 6½	0 17 6	0 17 7½	0 17 7½	0 17 6	0 17 8
1929	0 17 7½	0 18 0	0 19 0	0 19 6½	0 18 10½	0 19 10½	1 1 3½	1 1 8½	1 3 0	1 3 6	1 3 8	1 3 1½	1 0 9½
1930	1 2 6½	1 1 3	1 0 3	0 19 1½	0 17 7	0 16 10½	0 16 6	0 16 6	0 16 9	0 17 0	0 17 0	0 17 0	0 18 2½
1931	0 17 0	0 16 7½	0 16 0	0 16 0	0 15 11	0 15 5	0 15 1	0 15 0	0 15 0	0 16 9	0 17 0	0 16 6	0 16 0½
1932	0 17 0	0 16 11½	0 16 5½	0 15 9	0 15 7½	0 15 6	0 15 6	0 14 9½	0 14 6½	0 14 6	0 14 6	0 15 4	0 15 6½
1933	0 16 0 ½	0 15 9½	0 15 6½	0 15 3	0 15 3	0 15 6	0 15 6	0 15 7½	0 16 1	0 17 0	—	—	—

* Strike period. ‖ Five months.

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